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Report on

'SMART CONTACTLESS VENDING MACHINE FOR COLLEGES'

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PROGRAM - B.TECH

CERTIFICATE

This is to certify that the Report entitled

'SMART CONTACTLESS VENDING MACHINE FOR COLLEGES'

is a bonafide work carried out by

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In partial fulfillment for the completion of 7th semester course work in the Program of Study B.Tech in Electronics and Communication Engineering under rules and regulations of PES University, Bengaluru during the period Jan - May & Aug – Dec 2023. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report. The report has been approved as it satisfies the academic requirements in respect of project work.

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DECLARATION

We, **Punati Roopesh (PES1UG20EC146) , Ankit Raj Amberkar (PES1UG20EC251) Khaja Tippusultan (PES1UG20EC257) , Rahul (PES1UG20EC262)** hereby declare that the report entitled, **'Smart Contactless Vending Machine for Colleges'**, is an original work doneby us under the guidance of **Prof. Rekha S S, Assistant Professor, ECE department** is being submitted in partial fulfillment of the requirements for completion of project work in the Program of Study B.Tech in Electronics andCommunication Engineering.

PLACE:

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NAME AND SIGNATURE OF THE CANDIDATES

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ABSTRACT

In this project, we present an innovative paradigm shift in the deployment of real-world Smart Contactless Vending Machine for Colleges systems, specifically tailored for vending machines. Our focus extends beyond the conventional, introducing a revolutionary approach to mobile proximity payments at unattended points of sale.

Our visionary concept revolves around the creation of a digital representation of vending machines on the Internet, empowering users to make contactless transactions effortlessly using their smartphones. The distinguishing feature of our approach lies in its seamlessness – customers can place orders without any direct interaction with the vending machine, ensuring a fully immersive and convenient experience.

Crucially, our system employs a foolproof mechanism to guarantee that transactions and product dispensing occur only when the consumer is physically proximate to the vending machine. By intertwining principles of open innovation, ubiquitous connectivity, and leveraging pervasive technologies, we've meticulously crafted a cost-effective solution. Our mission is clear: to drive down the Total Cost of Ownership for vending operators, while simultaneously elevating the consumer purchasing journey.

Our ultimate aspiration is to redefine the landscape of vending operations, enhancing consumer satisfaction, and propelling the widespread adoption of what we term the "Smart Contactless Vending Machine for Colleges." Welcome to the future of automated, intelligent retail experiences, where technology seamlessly blends with consumer convenience, setting the stage for a new era in retail innovation.

Table of contents

List of figures

1. Introduction

In the labyrinthine landscape of the vending industry, we find ourselves amidst a diverse tapestry of small and medium enterprises (SMEs), each striving to carve out a niche in a market largely dominated by a handful of multinational behemoths. The battleground is not just competitive; it's a mosaic, with thousands of SMEs scattered across every country. Within this vibrant ecosystem, profit margins are paper-thin, turning any foray into cutting-edge technologies into a high-stakes juggling act that demands significant scale for validation.However, the true conundrum in this fragmented market lies in a paradox – the very innovations that could streamline operational costs are often viewed as perilous endeavors by most modest vending operators. The economic landscape, underscored by the current costs of technology, breeds caution, casting a shadow of doubt over the willingness of these operators to embrace transformative technologies.

In the face of this dichotomy, our mission extends beyond merely introducing advanced technologies; it's about reshaping the relationship between scale, innovation, and sustainability. We embark on a journey to unlock the dormant potential within the realm of small vending enterprises, bridging the gap between time-honored practices and cutting-edge solutions. Our strategy recognizes the nuanced intricacies of the market, plotting a distinctive course that transforms hesitancy into enthusiasm, propelling small players confidently into the future of vending.

As we navigate this uncharted expanse, we acknowledge the imperative of making technology investments not just available but practical, tailored to the specific needs of smaller players. Our goal is not solely to revolutionize vending operations but to democratize the adoption of advanced technologies, cultivating an ecosystem where innovation transcends the constraints of scale. Welcome to a new era where the fragmented becomes interconnected, and the hesitant emerge as pioneers in the unfolding narrative of

the future of vending.Utilizing the compact and web-capable Raspberry Pi as the core computing unit, the vending machine establishes a robust connection between the web application and physical components. The choice of Flask, a lightweight web framework for Python, ensures the development of a responsive and efficient user interface.Assigning unique identifiers to each product, the system generates dynamic QR codes through the Flask application. These QR codes encapsulate essential information, such as product details and pricing, providing a digital representation of the products. The web application hosts a user-friendly interface, enabling effortless product browsing, selection, and QR code generation. The emphasis is on delivering a seamless experience that allows users to initiate transactions with ease. Users can employ smartphones or dedicated QR code scanners to read the dynamically generated QR codes. The information stored in these codes is leveraged to identify the selected product, initiating the subsequent steps in the vending process. Dispensing is controlled and secure, triggered only upon successful QR code scans. QR codes are validated against a database to ensure correspondence with valid products. Robust security measures, including encryption and authentication protocols, are implemented to prevent unauthorized transactions or tampering. The hardware components include a Raspberry Pi 3b+, Pi Cam, and a 5V DC motor, forming a cohesive system for efficient operation. The Raspberry Pi's capabilities, such as Wi-Fi connectivity and GPIO access, make it a suitable choice for hosting the vending machine system. The software stack comprises Python 3.10.0, Flask framework, Raspbian OS, Python IDLE, HTML, CSS, and Flask for web development. Each component contributes to the development and functionality of the Smart Contactless Vending Machine. The subsequent sections delve into the detailed specifications of the hardware components, emphasizing the capabilities of the Raspberry Pi 3b+, Pi Cam, and the 5V DC motor. Additionally, the software requirements highlight the significance of Python, Flask, HTML, and CSS in creating a versatile and user-friendly vending machine system. In conclusion, the Smart Contactless Vending Machine project aims to revolutionize vending experiences within academic institutions, providing a modern, efficient, and secure solution. The integration of cutting-edge technologies, both in hardware and software, ensures a seamless and user-friendly vending process, meeting the diverse needs of college and university communities.

2. Literature Survey

Solar Powered Medic Vending Machine [1]

This project introduces a solar-powered medical vending machine, strategically designed to dispense first-aid items and essential medicines in areas with limited access to pharmacies. The machine incorporates various technological features to ensure user authentication, hygiene, and reliable operation, making it suitable for deployment in public spaces such as metro stations, railway stations, highways, and organizations. The primary goal is to address the lack of first-aid kits during emergencies, particularly in rural areas.

The technology used in our solar-powered medical vending machine is designed to make it efficient, secure, and user-friendly. It includes a magnetic card module for authentication and security, a hand sanitizing feature with UV sensors and servo motors for hygiene, and a body temperature check-up using a digital infrared thermometer. The machine operates on solar energy, ensuring sustainability with a 12V solar source. An auto failure detection system uses an IR sensor to identify dispensed items, and users can select products using a keypad. The power saver mode, activated by a magnetic card, helps conserve energy, while LED lights enhance product visibility at night. The machine offers a large storage capacity for additional medicines and kits, and the product dispensing section uses an IR sensor for efficient product detection.

In terms of features, the machine also incorporates a magnetic card reader for security and power-saving, UV sensors, and servo motors for hand sanitizing, a digital infrared thermometer for temperature check-up, and automatic on/off through power saver mode. It features self-detection for dispensed items, solar panels for power supply, LED strips for night visibility, photoelectric transducers for day/night sensing, and a spacious storage area

for additional items.

For future improvements, we aim to enhance security measures tailored to different locations, integrate advertisements for organizational use, optimize the charge controller for extended battery life, and expand the product range within the vending machine.

However, there are some drawbacks. The paper lacks explicit details on testing procedures and results, and there is limited information on the scalability of the system. The reliance on a magnetic card for user access may pose a barrier in emergency situations.

In conclusion, our solar-powered medical vending machine effectively addresses the shortage of first-aid kits in various locations, providing a user-friendly and portable solution. By combining technology, renewable energy, and hygiene features, it offers immediate medical assistance. Future improvements have the potential to enhance its utility and adaptability in diverse settings.

Research and Application on Vending Machine Data Integration Based on EPC System[2]

Vending machines have experienced a surge in popularity within the retail sector due to technological advancements and economic growth. The integration of Electronic Product Code (EPC) and Internet of Things (IoT) is pivotal for enhancing the efficiency and intelligence of these machines.

The central focus lies in the synergy between EPC and IoT, demonstrating how their

combination establishes connections between virtual networks and the physical objects represented by vending machines. This interconnectedness allows information to seamlessly travel through wireless communication networks, significantly impacting decision-making processes in managing vending machine operations.

Within the EPC system, key components contribute to this integration. The EPC Tag Data Standard ensures a global identification for items, while the EPC Identification System (EPCIS) minimizes manual intervention. The Information Network System manages product information through middleware such as Object Naming Service (ONS) and Physical Markup Language (PML).

On the IoT front, a wireless object network architecture links vending machines to the Internet using GPRS/CDMA for efficient data exchange. Data encapsulation middleware employs Web Service-based techniques, involving a mediator, metadata, and wrappers. The EPC Identification Format and Data Encapsulation Format, utilizing PML, play a crucial role in standardizing information related to vending machines.

Key takeaways include the goal of achieving global identification, the efficiency of middleware in reducing network traffic, the utilization of Web Service middleware for dynamic connections, and the adoption of PML for standardized, straightforward language in describing information.

Looking towards the future, improvements aim to accommodate dynamic environments, integrate advanced data mining models for decision support, and address challenges associated with the unique requirements of each vending machine, data complexity, and operational hurdles.

In conclusion, this project explores the convergence of EPC, IoT, and information technology to elevate the efficiency and intelligence of vending machine operations. It not only sheds light on the current state of integration but also serves as a reference model for potential applications and enhancements in the future.

The Cashless Payment Device for Vending Machines -Import Substitution in the Sphere of Vending[3]

In this paper, we explore the significance of vending machines and their role in offering products and services through automated systems. Specifically, we delve into the development of a cashless payment device designed to enable employees to make purchases using electronic passes. The primary goals are to expedite customer service, mitigate issues related to cash handling, and boost the organization's revenue.

The technology used in this cashless payment device includes RFID technology (MIFARE and EM-Marin cards) for non-cash transactions in vending machines. RFID, or Radio Frequency Identification, facilitates communication with cards or keys for various purposes, such as access control, attendance tracking, and financial transactions. Serial interfaces with protocols like MDB/ICP enable communication between the vending machine and the cashless payment device. Additionally, Ethernet and WiFi communication are employed to connect the device to servers for card authentication and balance inquiries. The implementation also features a dual-processor system, using separate processors for vending equipment communication and server interaction to enhance flexibility and functionality.

Key points highlight the user convenience, offering a seamless "one-touch" payment method that saves time and eliminates the need for physical cash or additional tools. For vending companies, benefits include a reduction in issues related to cash handling, change provision, and maintenance of cash flow. This, in turn, leads to increased sales and a broader customer base. The flexible implementation of this system has been successfully demonstrated in state institutions, showcasing its adaptability in real-world scenarios. The improvement in customer service is evident through a simplified purchasing process, elimination of cash concerns, and enhanced service speed. Sales growth over time indicates user acceptance and potential market expansion.

Looking ahead, the paper suggests future improvements, such as integrating with newer contactless payment technologies or mobile payment methods, enhancing security measures to prevent data breaches, minimizing overall implementation costs for accessibility to smaller businesses, ensuring adaptability to various institutional restrictions, and improving user feedback mechanisms.

However, there are also drawbacks to consider. The initial setup costs may be high due to specialized devices and protocols. Dependence on stable internet connections for real-time authentication and transactions could pose challenges in certain locations. Compatibility concerns may limit functionality in environments where specific technologies or devices are not supported. Security risks related to flaws in RFID or communication protocols pose potential threats to user data. Regular maintenance and upkeep, particularly for software updates and security patches, are necessary for smooth operation.

In summary, while this project showcases an innovative approach to cashless vending with strengths in convenience, adaptability, and potential market growth, it also faces challenges

related to cost, security, and compatibility that require attention for broader implementation and enhanced efficiency.

Smart Vending Machine Based on SMS Gateway For General Transactions[4]

The proposal discusses the need for innovation in vending machines for office supplies, particularly focusing on the limitations of traditional cash-based systems in Indonesia. It suggests a smart vending machine using SMS transactions, incorporating the TCASH digital payment service for security. The objective is to create an efficient, accessible, and secure vending machine solution for diverse user needs.

The technology involved includes common components like Arduino, a Wavecome SMS Gateway module, servos, power supply, keypad, and an LCD display. Additionally, a Wi-Fi module (Wemos d1) enables real-time online monitoring, and an early warning system with a battery backup ensures reliability during power disruptions.

Highlighting key points, the proposed system allows users to make transactions via SMS, ensuring accessibility across locations and network providers. Owners can monitor transactions in real time through an Android smartphone, and a backup power system enhances reliability. The use of TCASH mitigates issues associated with cash transactions.

Future improvements include enhancing the user interface, expanding payment options, increasing the product range, implementing predictive maintenance, and customizing functionalities for different regions.

Acknowledging drawbacks, the proposal notes limitations such as dependence on TCASH availability, potential technical issues, reliance on stable electricity, transaction costs for

SMS, and potential restrictions in areas with unstable telecommunication and internet connectivity.

In summary, the project presents a novel vending machine solution leveraging SMS-based transactions and TCASH for accessibility and security. While showcasing promising scalability and features like online monitoring, it acknowledges limitations related to accessibility and technical dependencies.

In conclusion, the project successfully implements a smart vending machine for office supplies, offering a seamless transaction process, online monitoring, and an early warning system. The potential for scalability and future improvements is recognized, alongside considerations regarding accessibility and technical dependencies.

A Novel Implementation of FPGA Based Smart Vending Machine[5]

This paper discusses the design and implementation of an FPGA-based vending machine using the Verilog HDL platform and a Mealy finite state model. In this vending machine, users first deposit the required money in a designated slot and then choose a single product at a time. If the inserted money is sufficient, the selected product is dispensed; otherwise, a message prompts the user to add more money or cancel the transaction.

The technology employed in this project includes the use of the FPGA Zed board xc7z020clg484-1 and Verilog HDL for implementation. Verification is conducted through the VIVADO HLX 2019.1 simulator, showcasing different scenarios. Finite State Machines (FSM) serve as the mathematical model for designing sequential logic circuits, and a Mealy Machine Model is selected for the vending machine's implementation. The

operational steps of vending machines in general are detailed as part of the technology overview.

Key aspects of the project are highlighted, covering the design methodology, simulation results, RTL schematic, utilization summary, and advanced features such as refund options, transaction cancellations, and unavailability messages.

Future improvements are suggested, including expanded features like card payment, QR code integration, and the ability to select multiple products. The adaptability of the algorithm for varying products and price fluctuations is emphasized, along with discussions on potential applications in different domains such as ticketing and recycling. The focus on enhancing user comfort is recognized as a driving factor for future improvements.

Drawbacks in the current design are acknowledged, including limitations in displaying a message only when certain notes are unavailable for change, the machine's behavior in specific scenarios like insufficient change for a refund, and the need for continuous adaptation to market changes and user preferences. Power utilization is also discussed, along with potential areas for optimization.

The summary section encapsulates the key points from the project, providing a recap of the vending machine design methodology, simulated scenarios, utilization and power summary, challenges, and future scope. The conclusion confirms the successful verification of the vending machine design using FPGA, recaps the advanced features incorporated, points out potential future directions, expresses gratitude to mentors and contributors, and ends with optimism about the future applications and improvements in vending machine technology.

New Generation Artificial Intelligent Vending Machine System based on LoRaWan IOT Network[6]

The rapid advancement of technology in today's era has elevated the significance of the Internet of Things (IoT) and artificial intelligence (AI) as pivotal elements of innovation. Within this landscape, machine learning, particularly in the domain of image recognition, has become indispensable, necessitating diverse models tailored to specific requirements. This paper delves into the integration of AI and IoT within vending systems, with a particular focus on ticket vending machines and veterans. The proposed system employs AI for age and gender identification, transmitting data through the LoRaWan IoT Network to a cloud server, enabling comprehensive analysis of customer behavior and merchandise sales.

The system architecture adopts a wide-area IoT approach, specifically leveraging the LoRaWAN architecture. Each vending machine, equipped with a LoRa module and camera, captures buyer images for AI-driven gender and age recognition. The collected data is then transmitted to a remote server for processing and statistical analysis via TCP/IP. A monitoring system, facilitated by LoRaWAN, provides users with an interface to observe the statuses of individual vending machines.

This paper introduces a value-added structure for vending machines, incorporating a Convolutional Neural Network (CNN) facial recognition system for buyer identification and LoRaWan IoT for efficient data transmission. The deep learning model, based on CNN networks, facilitates age and gender identification, thereby enhancing the vending machine's capability to tailor merchandise offerings. The system's architecture, relying on LoRaWAN, ensures wide coverage for monitoring individual vending machines,

contributing to a more insightful analysis of buyer demographics and preferences.

However, certain limitations accompany this approach, including potential challenges in accurately identifying unique buyer preferences due to the inherent complexity of human choices. Additionally, the reliance on facial recognition may raise privacy concerns among users. The paper acknowledges the importance of carefully considering these drawbacks in the implementation of such systems.

In summary, the paper outlines a sophisticated system that seamlessly merges AI and IoT technologies into vending machines, with a specific emphasis on age and gender identification for targeted merchandise sales. Through LoRaWAN, the system facilitates widespread monitoring and data transmission, providing a valuable tool for adjusting sales strategies and maximizing profits.

In conclusion, the integration of LoRaWan and AI technologies in smart vending machines presents a promising sales system. By leveraging facial recognition for buyer analysis, the vending machine system gains valuable insights into its market, enabling strategic adjustments for increased profitability. This combined approach not only enhances customer experience but also positions vending machines as intelligent retail entities capable of adapting to dynamic market conditions.

Contactless and Cashless Smart Vending Machine Integrated with Mobile Device[7]

The paper introduces a prototype contactless and cashless smart vending machine system to address emerging needs. Traditional vending machines only accept physical coins and cash, forcing customers to fumble for exact change. This has become inconvenient and

problematic during the COVID-19 pandemic as contactless purchases are safer. To solve these pain points, the authors developed a mobile app solution integrating with a simulated vending machine.

The system allows customers to fully connect to and order from vending machines through the mobile app. On the software side, Android Studio enabled building a seamless ordering UI and integration with a Firebase database for vital functions. The database maintains user profiles, purchase histories, and dynamic inventory stock levels that decrement with each order in real-time. On the hardware side, an Arduino Nano serves as the core processor controlling the dispensing mechanisms. Bluetooth communication enables pairing between customers' mobile devices and the machine.

Tests demonstrated the mobile software can establish a connection with the simulated hardware within 3 seconds while data transmission latency remains under 1 second otherwise. This validates the system potential in terms of contactless order placement and cashless digital payments. Removing physical currency contact reduces virus spread risk. Fully productizing the solution will still require hardening reliability, security, and compliance. But the innovation showcases upgraded capabilities for the new normal.

While the implemented prototype uses simulated vending machine hardware at this stage, the technology foundations have been proven. Transitioning the software and core system logic to work with actual industrial-grade vending machine components would involve reasonable adaptation efforts. More robust microcontrollers and embedded operating systems tout reliability advantages over Arduino boards better suited for final field deployment. Enhancing the mobile application itself poses additional opportunities as well.

Integrating digital wallet support allows leveraging existing fintech payment platforms that consumers already use daily. Streamlining the ordering flow using predictive and recommendation techniques further enhances convenience. Expanding to support wearables like smartwatches and heads-up displays aligns with technological and cultural trends. While the current proof-of-concept focuses on core vending transactions, consumers and vendors alike stand to benefit from additional innovations incorporated together into one seamless smart vending solution.

Medicine Vending Machine[8]

The paper details a proof-of-concept prototype for ZhardEM, an automated medicine vending machine aimed at addressing a lack of 24/7 access to basic medicines on a university campus. Students living in dorms often face health issues like headaches or colds late at night when the campus medical center and pharmacy are closed. ZhardEM provides a solution – a stand-alone dispenser allowing self-service purchasing of essential over-the-counter medicines without needing a pharmacist or other staff.

The core of ZhardEM is the Arduino M0 microcontroller, chosen for its favorable balance of capability and cost. The M0 runs the dispensing mechanisms, handles payment processing, and controls the user interaction logic. Customers first feed coins into a slot, which an infrared LED and matching phototransistor sensor reads to add money to an internal credit register. Pressing either of two buttons then initiates a dispense from one of the integrated electric motors.

One motor is a servo rotating an arm to push single tablet-form pills from a stacked column, vending them individually. The other is a DC motor turning a spring-loaded spindle to

release measured powdered medicine packets. Testing demonstrated successfully dispensing both medicine types this way upon valid coin payment insertion. But the prototype only supports two medicine options currently, offering significant room to expand the selection.

While proving the automated, pharmacist-free medicine vending concept overall, the paper notes limitations around robustness for real-world usage. The system relies on multiple separate power sources rather than a unified supply. And ambient light can interfere with the infrared coin sensor, compromising reliability. Beyond hardware improvements, features like internet connectivity for remote monitoring and restock notifications represent major functionality upgrades as well.

Still while an initial proof of concept, ZhardEM successfully tackles the key challenges of enabling automated, self-service access to essential medicines without staff. The innovations fill a major void in health resources, providing 24/7 availability and convenience for students. With upgrades to integration, ruggedization, and security, the paper shows strong potential for commercializing the machine to campuses and other locations lacking round-the-clock pharmacy access.

3. Proposed Methodology

3.1. Raspberry Pi Web Deployment:

- Utilizing a Raspberry Pi: The choice of Raspberry Pi is driven by its compact size and robust web connectivity capabilities, making it an ideal platform for hosting the vending machine system. The Raspberry Pi acts as the central processing unit, facilitating communication between the web application and the vending machine components.
- Employing Flask: The implementation of Flask, a lightweight web framework for Python, is pivotal in creating a responsive and efficient web application. Flask allows for the development of a user interface that seamlessly interacts with the vending machine system, providing a user-friendly experience.

3.2. QR Code Generation:

- Unique Product Identifiers: Every product in the vending machine is assigned a unique identifier, ensuring a distinct association with each item.
- Dynamic QR Code Generation: The Flask application dynamically generates QR codes based on the unique product identifiers. These QR codes serve as digital representations of the products, encapsulating essential information such as product details and pricing.

3.3. Web Interface:

- User-Friendly Interface: The web application hosts a user-friendly interface that enables users to effortlessly browse available products, make selections, and view associated QR codes.
- Seamless User Experience: The goal is to provide a seamless experience, allowing users to initiate transactions and generate QR codes for their chosen products with ease.

3.4. QR Code Scanning:

- Device Compatibility: Users can utilize their smartphones or dedicated QR code scanners to read the dynamically generated QR codes presented by the web application.
- Leveraging QR Code Information: The information stored in the QR codes is leveraged to identify the selected product, initiating the subsequent steps in the vending process.

3.5. Product Dispensing Machine:

- Integration with Vending Machine: The vending machine is intricately linked to the Raspberry Pi and Flask application, establishing a communication bridge. This integration ensures seamless coordination between the web interface and the physical dispensing mechanism.
- Controlled Dispensing System: The system is designed to be secure and controlled, with product dispensing triggered only upon successful QR code scans. This linkage guarantees a synchronized and error-free vending process.

3.6. Transaction Verification:

- QR Code Validation: The scanned QR codes are verified against a database to ensure their correspondence with valid products within the vending machine inventory.
- Security Measures: Robust security measures are implemented to prevent unauthorized transactions or any potential tampering with the vending system. This includes encryption, authentication protocols, and transaction logs for auditing purposes. The verification process adds an extra layer of assurance, safeguarding the integrity of the vending transactions.

4. Implementation

4.1. Hardware Requirements

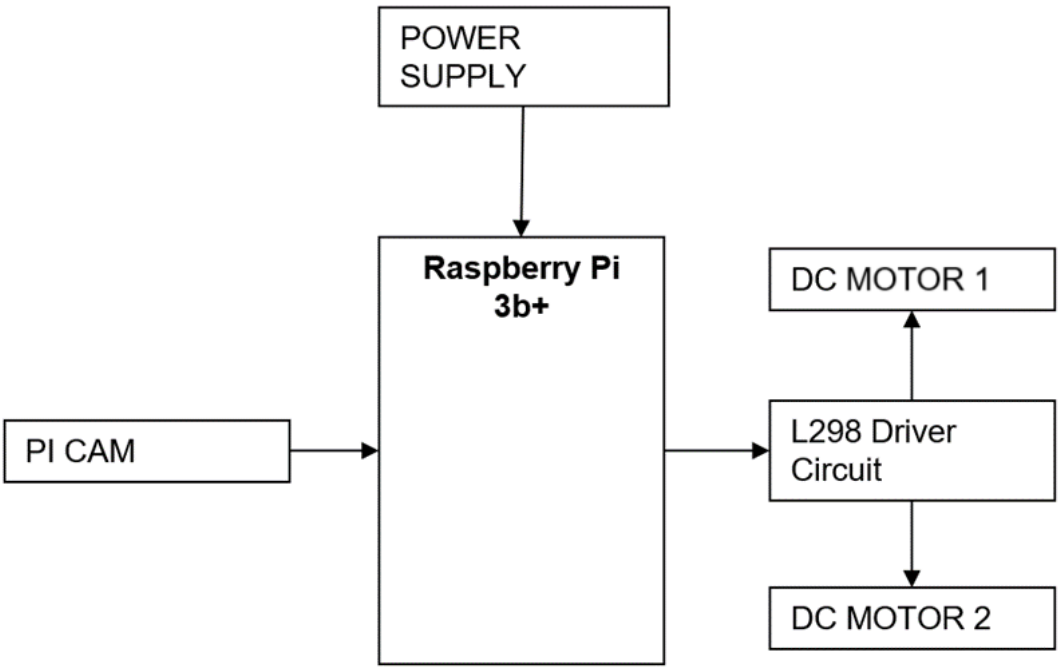

Fig 1 Hardware Block Diagram

4.1.1. Raspberry Pi 3b+

Raspberry Pi 3 employs the Broadcom BCM2837 SoC with a powerful 1.2GHz 64-bit quad-core ARM Cortex-A53 processor.

- **Performance**

  The quad-core Cortex-A53 processor in Raspberry Pi 3 is touted to deliver a performance ten times superior to its predecessor.

- **Overclocking**

  Overclocking options for Raspberry Pi 3 include presets like 1100MHz ARM, 550 MHz core, 500MHz SDRAM, and a 6-volt overvolt.

- **Networking**

  Equipped with 2.4 GHz Wi-Fi 802.11n (150 Mbit/s) and a 10/100 Ethernet port, Raspberry Pi 3 ensures versatile connectivity options.

Advanced Features

- **RAM**

  Raspberry Pi 3 boasts 1GB of RAM, a notable improvement from its previous versions.

- **GPU (Graphical Processing Unit)**

  The GPU of Raspberry Pi 3 can operate at different frequencies: 250 MHz for video core 4, 300 MHz for the 3D part, and 400 MHz for the video part.

- **HDMI Port**

  Featuring High Definition Multimedia Interface (HDMI), Raspberry Pi 3 facilitates the transfer of uncompressed video and audio data, making it compatible with various display devices.

- **CSI Port (Camera Serial Interface)**

  Raspberry Pi 3 includes a CSI port, enabling the connection of a small camera to the BCM2837 processor. This port establishes an electrical bus connection between two devices, with video inputs array of capabilities contribute to its popularity in the maker and hobbyist communities.

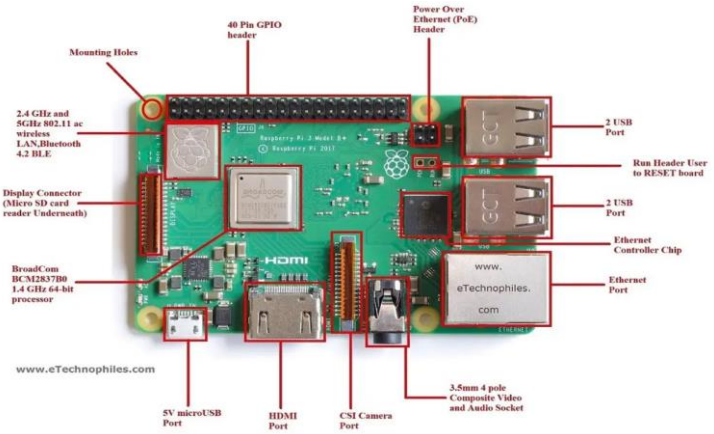

Fig 4.1 Raspberry Pi 3+

- **Pin Configuration and GPIO**

  Pin Configuration:

  Fig. 4.2 illustrates the pin configuration of Raspberry Pi 3, encompassing 26 GPIO pins, 4 DC power supply pins (2 at 3.3V and 2 at 5V each), 8 ground pins, and 2 pins for ID_SC.

  GPIO (General Purpose Input Output)

  GPIO pins, standing for General Purpose Input Output, serve versatile purposes beyond the specified configurations.

- **Conclusion**

  In summary, Raspberry Pi 3 stands as a versatile and powerful SBC with a rich set of features, making it suitable for diverse applications and projects. Its compact size, impressive performance.

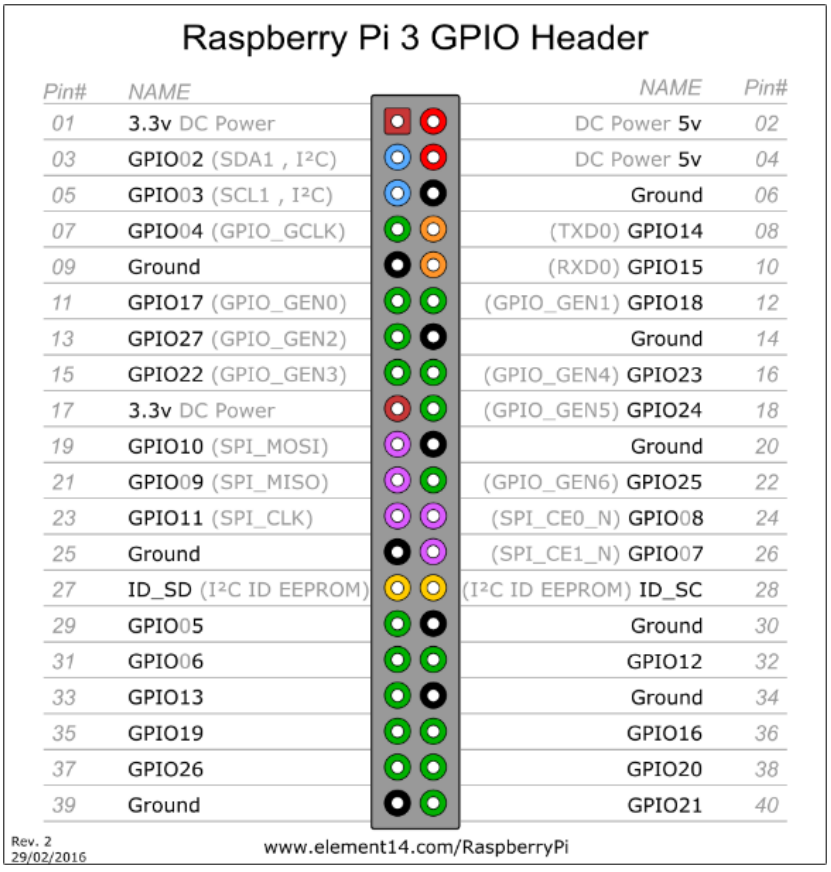

Fig 4.2 GIPO Ports

4.1.2. Pi Cam

The Raspberry Pi Camera, commonly referred to as Pi Cam, is a small, high-quality camera module designed specifically for use with Raspberry Pi single-board computers. Developed by the Raspberry Pi Foundation, the Pi Cam provides users with a compact and cost-effective solution for capturing images and video, expanding the capabilities of Raspberry Pi projects in various applications.

Features of the Raspberry Pi Camera:

- High Resolution: The Pi Cam is available in different models, offering varying resolutions. The higher-end versions provide impressive image and video quality, suitable for a range of applications from hobbyist photography to video streaming.
- Compact Design: The camera module is remarkably small, making it easy to integrate into Raspberry Pi projects without adding significant bulk. This compact design allows for flexibility in project configurations.
- Simple Connectivity: The camera connects directly to the dedicated camera port on the Raspberry Pi board, ensuring a straightforward and seamless integration process. This plug-and-play approach simplifies setup for users, even those with minimal technical experience.
- Real-Time Streaming: The Pi Cam supports real-time streaming, enabling users to capture and stream live video feeds directly from the Raspberry Pi. This feature is valuable for applications such as surveillance systems, remote monitoring, or live video broadcasting.

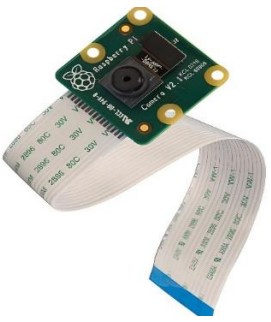

Fig 4.3 Pi Camera

4.1.3. DC Motor

A 5V DC motor is a type of electric motor that operates on a direct current (DC) power supply, specifically designed to work with a voltage of 5 volts. These motors find widespread use in various electronic applications, robotics, and small-scale projects due to their manageable voltage requirement and versatile performance.

Features of 5V DC Motor:

- Voltage Compatibility: The motor is engineered to operate efficiently with a 5V power source, making it compatible with standard low-voltage electronic systems.
- Compact Size: 5V DC motors are often compact and lightweight, making them suitable for applications where space is a critical factor.
- Affordability: These motors are cost-effective, providing an economical solution for projects with budget constraints.
- Ease of Integration: They are relatively easy to integrate into electronic circuits and systems due to their straightforward power requirements.
- Variable Speed Control: Some 5V DC motors come with features that allow for variable speed control, offering flexibility in different applications.
- Low Power Consumption: Designed for efficiency, these motors typically have low power consumption, making them suitable for battery-powered devices.

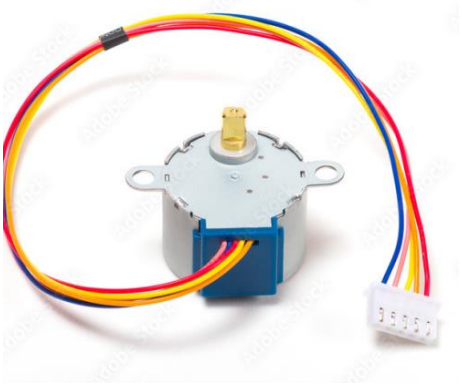

Fig 4.4 DC Motor

4.2. Software Requirements

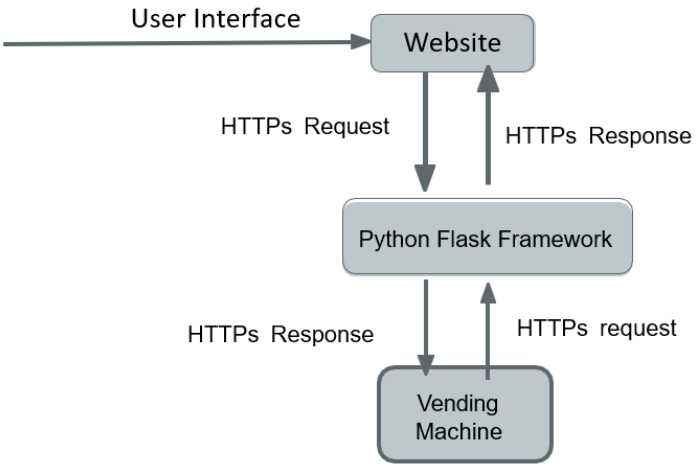

Fig 4.5 Software Block Diagram

4.2.1. Python IDLE

Python IDLE, which stands for Integrated Development and Learning Environment, is an integrated development environment that comes bundled with the Python programming language. It serves as a convenient tool for beginners learning Python and provides a simple yet effective environment for writing, testing, and debugging Python code.

Features of Python IDLE:

- Interactive Shell: Python IDLE includes an interactive shell, allowing users to execute Python commands and scripts line by line. This feature is particularly useful for testing code snippets and experimenting with Python concepts.
- Code Editor: The integrated code editor in Python IDLE provides syntax highlighting, auto-indentation, and other features that enhance code readability and make coding more efficient.
- Debugger: Python IDLE comes equipped with a built-in debugger, enabling developers to identify and fix errors in their code step by step. This is especially helpful for troubleshooting complex programs.
- Script Execution: Users can run entire Python scripts directly from the IDLE

environment, making it easy to execute and test larger programs without the need for a separate command-line interface.

- Integrated Documentation: Python IDLE offers access to Python's extensive documentation. Users can quickly look up information about functions, modules, and Python language features without leaving the IDE.
- GUI Development: Python IDLE supports the development of graphical user interfaces (GUIs) using the Tkinter library. Developers can create interactive and visually appealing applications with ease.
- File Explorer: The IDE includes a file explorer that allows users to manage their Python files and projects efficiently. It provides a convenient way to navigate through directories and organize code files.

4.2.2. Raspbian OS

Raspbian is an operating system specifically designed for the Raspberry Pi single-board computers. It is the official and recommended operating system for Raspberry Pi devices. Raspbian is a Debian-based Linux distribution tailored to the unique hardware and capabilities of the Raspberry Pi. It provides a user-friendly environment for both beginners and experienced users, making it a popular choice for various projects and applications.

Features of Raspbian OS:

- Debian Base: Raspbian is built upon the stable foundation of Debian Linux, ensuring reliability, security, and access to a vast repository of software packages.
- Optimized for Raspberry Pi: The operating system is optimized to take full advantage of the Raspberry Pi's hardware, including its ARM architecture, GPIO pins, and other specific features.
- User-Friendly Interface: Raspbian features a user-friendly desktop environment, making it accessible for users with varying levels of experience. The graphical user interface (GUI) simplifies navigation and interaction.

- Pre-installed Software: Raspbian comes with a suite of pre-installed applications, including a web browser, text editor, and programming tools. This makes it convenient for users to start working on projects without the need for extensive installations.
- Programming Support: It includes programming tools and languages like Python, Scratch, and Thonny, making it an excellent choice for educational purposes and programming projects.
- Configuration Tools: Raspbian provides easy-to-use configuration tools that allow users to customize various system settings, network configurations, and peripherals.
- GPIO Access: Raspbian allows easy access to the General Purpose Input/Output (GPIO) pins of the Raspberry Pi, facilitating the development of hardware projects and interfacing with external devices.

4.2.3. Python

Python is a high-level, general-purpose programming language known for its readability, simplicity, and versatility. Created by Guido van Rossum and first released in 1991, Python has since become one of the most popular programming languages globally. It emphasizes code readability and encourages a clean, expressive coding style, making it an excellent choice for beginners and experienced developers alike. Python's design philosophy prioritizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than languages like C++ or Java.

Features of Python:

- Readability: Python's syntax is designed to be readable and concise, promoting code clarity and reducing the cost of program maintenance.
- Versatility: Python supports multiple programming paradigms, including procedural, object-oriented, and functional programming. This flexibility allows

developers to choose the approach that best fits their needs.

- Extensive Libraries: Python boasts a vast standard library that covers areas such as file handling, networking, web development, and more. This extensive collection of modules facilitates rapid development and reduces the need for writing code from scratch.
- Dynamically Typed: Python is dynamically typed, meaning variable types are assigned during runtime. This enhances flexibility but requires careful consideration of data types in the code.
- Interpreted Language: Python is an interpreted language, which means that code execution occurs line by line. This facilitates rapid development and debugging, as changes take effect immediately.
- Community Support: Python has a vibrant and active community, contributing to a wealth of resources, tutorials, and third-party libraries. The community's collaborative nature fosters continuous improvement and innovation.
- Platform Independence: Python is platform-independent, meaning Python code can run on various operating systems without modification, enhancing its portability.

4.2.4. WEB- HTML, CSS.

HTML (HyperText Markup Language):

HTML, or HyperText Markup Language, is the standard markup language used to create and design web pages. Developed by Tim Berners-Lee in 1991, HTML provides a structure for content on the World Wide Web. It uses a system of tags to define elements such as headings, paragraphs, links, images, and more. HTML forms the backbone of web development, allowing developers to create well-organized documents by structuring content and establishing relationships between different elements.

Features:

- Document Structure: HTML provides a hierarchical structure for web documents, defining elements like headings, paragraphs, lists, and more.
- Hyperlinks: Hyperlinks enable the creation of navigable links between different pages, allowing users to move seamlessly through a website.
- Multimedia Integration: HTML supports the embedding of multimedia elements such as images, audio, and video to enrich the content of web pages.
- Forms: HTML includes form elements like text fields, checkboxes, and radio buttons, facilitating user interaction and data submission.
- Semantic Markup: HTML incorporates semantic tags to convey the meaning of content, aiding accessibility and search engine optimization.

CSS (Cascading Style Sheets):

CSS, or Cascading Style Sheets, is a style language used to describe the presentation of a document written in HTML. Developed to separate the structure of a document from its presentation, CSS allows developers to control the layout, appearance, and formatting of HTML elements. By applying styles such as colors, fonts, and spacing, CSS enhances the visual appeal and consistency of web pages.

Features:

- Selectors: CSS uses selectors to target HTML elements for styling.
- Box Model: Elements are treated as boxes, and CSS provides control over dimensions, margins, borders, and padding.
- Flexbox and Grid Layout: Advanced layout models like Flexbox and Grid offer powerful tools for creating responsive and dynamic page layouts.
- Typography: CSS allows customization of fonts, sizes, colors, and spacing for text elements.
- Transitions and Animations: CSS enables the creation of smooth transitions.

4.2.5. Flask Framework

Flask is a lightweight web framework for Python, known for its simplicity, flexibility, and ease of use in building web applications. Developed by Armin Ronacher, Flask is designed to be minimalistic yet powerful, allowing developers to create robust web applications with a straightforward and modular structure.

Flask operates on the principle of simplicity, providing essential tools for web development without imposing a rigid structure. It is categorized as a micro-framework, meaning it focuses on the core components needed for web development and leaves additional functionalities to be added as extensions. This minimalistic approach makes Flask an excellent choice for both beginners and experienced developers seeking a framework that adapts to various project requirements.

The framework's core features include routing, template rendering, and request handling, allowing developers to define routes, render HTML templates, and handle HTTP requests with ease. Flask follows the WSGI (Web Server Gateway Interface) standard, ensuring compatibility with various web servers.

One of Flask's notable strengths is its integrated Jinja2 templating engine, which simplifies the rendering of dynamic content in HTML templates. This feature enhances code readability and maintainability, enabling the creation of dynamic web pages with minimal effort.

Flask's modular design also supports the use of extensions, enabling developers to add features like authentication, databases, and RESTful API capabilities seamlessly. This flexibility ensures that Flask remains lightweight while catering to a wide range of project needs.

Features:

Flask's features revolve around its simplicity, extensibility, and the philosophy of providing the tools needed without imposing unnecessary structure. Here are some key concepts and usage patterns:

- Micro Framework: Flask is often referred to as a "micro" framework because it focuses on simplicity and leaves many decisions to the developer. This micro-framework approach provides the flexibility to choose and integrate components based on project requirements.
- Jinja2 Templating: Flask integrates with the Jinja2 templating engine, allowing developers to create dynamic and reusable HTML templates. This separation of logic and presentation enhances code readability and maintainability.
- Routing: Flask provides a straightforward and intuitive routing system. Developers can define URL patterns and associate them with specific functions (views) in the code, making it easy to map URLs to specific functionalities within the application.
- Built-in Development Server: Flask comes with a built-in development server, making it convenient for developers to test and debug their applications during the development phase. While not suitable for production, it serves as a quick and easy way to get started.
- Extensibility: Flask allows developers to easily extend its functionality through various extensions. These extensions cover a wide range of features, such as database integration, authentication, and form handling, providing modular solutions for common web development tasks.
- Werkzeug Integration: Flask is built on top of the Werkzeug WSGI toolkit, which provides the foundation for handling HTTP requests and responses. This integration ensures robust and efficient handling of web-related tasks.
- RESTful Request Handling: Flask supports the development of RESTful APIs out

of the box. With its simplicity and support for HTTP methods, developers can easily create APIs for their applications.

- Routing and Views: Developers define routes using the @app.route() decorator, associating URLs with corresponding functions (views). Views process requests and return responses, such as rendering templates or providing JSON data.
- Templates: Flask uses Jinja2 templates to dynamically generate HTML content. Templates allow developers to embed variables and control structures within HTML, facilitating the creation of dynamic web pages.
- Extensions: Flask extensions enhance functionality. For instance, Flask-WTF for form handling or Flask-SQLAlchemy for database integration can be easily added to extend the capabilities of the application.
- Deployment: In production, Flask applications are deployed using WSGI servers like Gunicorn or uWSGI. Deployment involves configuring the server, setting up environment variables, and ensuring proper security measures.

5. Result and Analysis

Smart vending machines, gaining popularity for their ability to enhance user experiences and streamline operations, are exemplified by the "Smart Contactless Vending Machine for Colleges" project. This innovative system, leveraging a Raspberry Pi-based architecture, introduces advancements that position it as a superior alternative to traditional vending machines. The use of Raspberry Pi 3 as the core computing unit represents a technological leap, offering compact size, potent processing capabilities, and web connectivity for seamless communication between the web application and vending components. Additionally, the implementation of dynamic QR codes for product identification and transactions underscores a forward-looking approach, enhancing user convenience through efficient and contactless interactions.

Analyzing various facets, including technology, user interaction, security, and adaptability, the project demonstrates noteworthy strengths. Prioritizing a user-friendly interface and QR code scanning with smartphones or dedicated scanners enhances the overall user experience, contrasting sharply with the limited interfaces of traditional machines. Furthermore, robust security measures, such as QR code validation and encryption, set a high standard for security, a feature lacking in conventional vending machines. The integration of Raspberry Pi and Flask Framework as the project's hardware and software backbone ensures a cohesive system for efficient product dispensing, addressing potential operational inefficiencies found in traditional vending machines. With an emphasis on digitalized payment options, reduced human intervention for inventory updates, and the introduction of a document printing facility, the project stands out for its adaptability, sustainability, and multi-functionality, setting it apart from traditional vending machines limited to dispensing physical products.

6. Conclusion and Future Directions

In conclusion, the development of the Smart Contactless Vending Machine for colleges presents a significant leap towards enhancing the vending experience in educational institutions. The project successfully addresses the problem of providing a smart, low-powered vending machine with fully digitized payment options tailored for universities and colleges.

The proposed methodology, employing Raspberry Pi and Flask, demonstrates a thoughtful integration of hardware and software components. The utilization of Flask, a lightweight web framework, proves instrumental in creating a responsive and user-friendly web interface. The dynamic QR code generation and scanning mechanism contribute to a seamless user experience, allowing for convenient product selection and transaction initiation.

The integration of the Raspberry Pi with the vending machine's mechanical components ensures a controlled dispensing system. The inclusion of a QR code validation step adds an extra layer of security, preventing unauthorized transactions and safeguarding the integrity of the vending process. The project's implementation, as depicted in the hardware block diagram, showcases a well-thought-out design that leverages Raspberry Pi 3b+, Pi Cam, and a 5V DC motor.

On the software side, the reliance on Python, Raspbian OS, and Flask showcases a robust software stack. Python's readability and versatility make it a suitable choice for developing the vending machine's logic, while Raspbian OS provides an optimized operating environment for Raspberry Pi. Flask's lightweight nature and extensibility contribute to the

efficiency of the web application.The inclusion of Python IDLE, serving as an integrated development environment, ensures a convenient platform for coding, testing, and debugging. The software block diagram encapsulates the synergy between these components, emphasizing a well-integrated and efficient system.

Future Scope:

Looking ahead, the Smart Contactless Vending Machine for colleges presents several avenues for future refinement and expansion. One potential direction involves enhancing payment options by integrating additional digital methods like mobile wallets and contactless cards, broadening the spectrum of user preferences. Another prospect is the integration of machine learning algorithms for predictive inventory management, utilizing historical data and usage patterns to optimize stock levels. Advanced security measures, including biometric authentication or facial recognition, could be implemented to fortify user authentication and prevent unauthorized access. Additionally, introducing customization features for users to personalize their vending experience, implementing remote monitoring for administrators, exploring energy-efficient components, and collaborating with campus systems for seamless access and payment integration are areas poised for further development.

In summary, the Smart Contactless Vending Machine establishes a foundation for innovative advancements in vending technology. The convergence of smart hardware, versatile software, and user-friendly design not only positions the project as a promising solution for modernizing vending services in educational settings but also opens up possibilities for market expansion beyond educational institutions. The envisioned future developments aim to enrich user experience, enhance security, and embrace sustainability, reflecting a commitment to staying at the forefront of technological evolution in the vending industry.

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SMART CONTACTLESS VENDING MACHINE FOR COLLEGES

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***Abstract*—** In this project, we present an innovative paradigm shift in the deployment of real-world Smart Contactless Vending Machine for Colleges systems, specifically tailored for vending machines. Our focus extends beyond the conventional, introducing a revolutionary approach to mobile proximity payments at unattended points of sale.

Our visionary concept revolves around the creation of a digital representation of vending machines on the Internet, empowering users to make contactless transactions effortlessly using their smartphones. The distinguishing feature of our approach lies in its seamlessness – customers can place orders without any direct interaction with the vending machine, ensuring a fully immersive and convenient experience.

Crucially, our system employs a foolproof mechanism to guarantee that transactions and product dispensing occur only when the consumer is physically proximate to the vending machine. By intertwining principles of open innovation, ubiquitous connectivity, and leveraging pervasive technologies, we've meticulously crafted a cost-effective solution. Our ultimate aspiration is to redefine the landscape of vending operations, enhancing consumer satisfaction, and propelling the widespread adoption of what we term the "Smart Contactless Vending Machine for Colleges." Welcome to the future of automated, intelligent retail experiences, where technology seamlessly blends with consumer convenience, setting the stage for a new era in retail innovation.

Keywords— digital representation, contactless transactions, proximate, consumer satisfaction

I. INTRODUCTION

In the evolving landscape of vending machine technology, traditional models equipped with RFID and magnetic card readers[1], coin or cash systems, and physical mechanisms are being reimagined to meet the demands of a digital age. This comparison explores the distinct characteristics of these traditional vending machines and contrasts them with a groundbreaking web-based vending machine project. The latter, built using Python and the Flask framework with a Raspberry Pi 3B as its central processing unit, introduces a paradigm shift in user interaction, payment flexibility, and inventory management. As the user orders items through a website, a QR code is generated, and upon scanning with a Raspberry Pi camera, the corresponding motor is triggered for item dispensation. This project's innovative approach offers a blend of modern convenience, real-time inventory tracking, and reduced physical maintenance. In this exploration, we delve into the unique features of both traditional and web-based vending machines, shedding light on their strengths and considerations, with the aim of understanding the implications for the future of vending technology.

II. OBJECTIVE

The primary objective of our innovative web-based vending machine project is to revolutionize the vending experience for students by introducing a streamlined and technologically advanced solution. The project is strategically designed to address several key challenges faced by students when interacting with traditional vending machines. Firstly, it aims to enhance time efficiency by enabling students to order their desired items in advance through a user-friendly website interface. This proactive approach eliminates the need for students to stand in line, saving valuable time for those with busy schedules. Additionally, the project focuses on reducing physical contact with the vending machine, aligning with current hygiene concerns and contributing to a cleaner and safer environment. The incorporation of a web-based ordering system facilitates contactless transactions, enhancing overall cleanliness. Lastly, the system offers document preparation convenience by providing a platform for students to upload files in advance, ensuring immediate access to printouts upon vending. In summary, our web-based vending machine project encompasses a comprehensive set of objectives, aiming to create a modern, convenient, and student-friendly vending solution that addresses key aspects of efficiency, cleanliness, sustainability, cost reduction, and document accessibility.

III. LITERATURE REVIEW

Traditional vending machines, such as those equipped with RFID and magnetic card readers[1], coin or cash systems, and physical mechanisms, have distinct characteristics. RFID and magnetic card reader machines offer the convenience of cashless transactions, but users are limited to possessing the corresponding physical cards or RFID tags[2]. Coin or cash machines, on the other hand, rely solely on physical currency for transactions. Physical vending

machines, while providing immediate access to products, lack the flexibility of digital interaction and are dependent on physical components[4].

In contrast, our web-based vending machine project introduces a modern and convenient user experience. By allowing users to interact with the vending machine through a website, it provides flexibility in payment options, including online transactions and digital wallets. The project's incorporation of QR code technology for item selection enhances the user-friendly interface, offering a more contemporary approach to vending machine interactions.

Maintenance and inventory management[2] represent significant differences between traditional vending machines and your web-based solution. Traditional machines require physical maintenance for restocking and addressing issues, with limited capabilities for real-time inventory tracking[2]. In contrast, your web-based vending machine enables real-time inventory tracking and management, reducing the need for frequent physical maintenance. Additionally, the potential for automated alerts or notifications for low stock or malfunctions enhances operational efficiency.

IV. METHODOLOGY

1) Raspberry Pi Web Deployment:

The choice of Raspberry Pi is driven by its compact size and robust web connectivity capabilities, making it an ideal platform for hosting the vending machine system. The Raspberry Pi acts as the central processing unit, facilitating communication between the web application and the vending machine components.The implementation of Flask, a lightweight web framework for Python, is pivotal in creating a responsive and efficient web application.

2) QR Code Generation:

Every product in the vending machine is assigned a unique identifier, ensuring a distinct association with each item. The Flask application dynamically generates QR codes based on the unique product identifiers. These QR codes serve as digital representations of the products, encapsulating essential information such as product details and pricing.

3) Web Interface:

The web application hosts a user-friendly interface that enables users to effortlessly browse available products, make selections, and view associated QR codes. The goal is to provide a seamless experience, allowing users to initiate transactions and generate QR codes for their chosen products with ease.

4) QR Code Scanning:

Users can utilize their smartphones or dedicated QR code scanners to read the dynamically generated QR codes presented by the web application. The information stored in the QR codes is leveraged to identify the selected product, initiating the subsequent steps in the vending process.

5) Product Dispensing Machine:

The vending machine is intricately linked to the Raspberry Pi and Flask application, establishing a communication bridge. This integration ensures seamless coordination between the web interface and the physical dispensing mechanism. Controlled Dispensing System: The system is designed to be secure and controlled, with product dispensing triggered only upon successful QR code scans. This linkage guarantees a synchronized and error-free vending process.

6) Transaction Verification:

The scanned QR codes are verified against a database to ensure their correspondence with valid products within the vending machine inventory. Robust security measures are implemented to prevent unauthorized transactions or any potential tampering with the vending system. This includes encryption, authentication protocols, and transaction logs for auditing purposes. The verification process adds an extra layer of assurance, safeguarding the integrity of the vending transactions.

7) Product dispensing section:

The device has large storage area, it has a printing module and a small section for product dispensing on QR code scanning using the onboard camera.

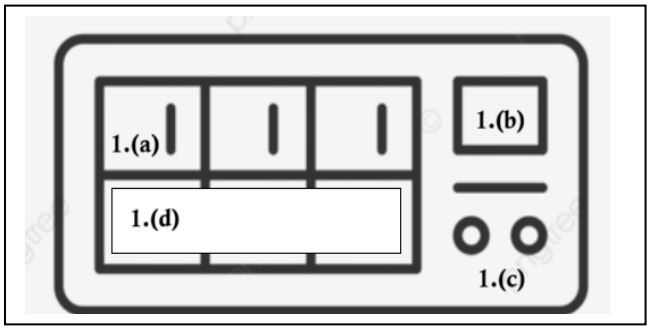

Fig. 1. Outer view of vending machine

1(a) denotes the products placed in the vending machine
1(b) denotes the camera module for QR scanning
1(c) denotes the lock of the machine to access the inside.
1(d) denotes the outlet of the machine for product dispensing and printed paper dispensing.

V. HARDWARE AND SOFTWARE BLOCK DIAGRAMS

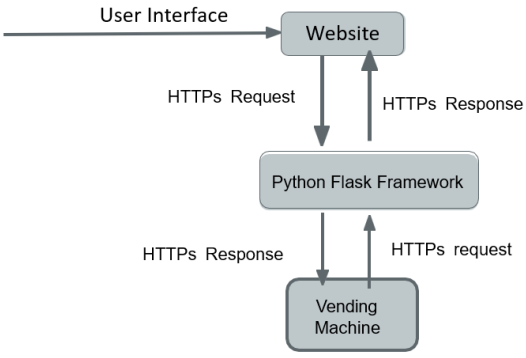

Fig. 2. Software data flow

VI. WORKING

The operation of our web-based vending machine project is characterized by a well-coordinated integration of web technologies, Python programming, and the capabilities of the Raspberry Pi 3B. Students initiate the process by accessing a user-friendly web interface developed using Python and the Flask framework, where they can browse available items, make selections, and place orders in advance. Upon successful order placement, the system generates a unique QR code,

representing the specifics of the order. When students arrive at the vending machine, they utilize the Raspberry Pi camera to scan the QR code from their devices, initiating the processing of order details. The Raspberry Pi 3B, functioning as the central processing unit, interprets the QR code data, extracting information about the ordered items, such as type, quantity, and any user-provided instructions. Subsequently, the system activates the corresponding motors responsible for dispensing the selected items, ensuring accurate and efficient retrieval from designated slots within the vending machine. The use of the Raspberry Pi 3B contributes to overall power efficiency, aligning with sustainability goals. Real-time inventory tracking is maintained, automatically updating as items are dispensed. The system also facilitates document preparation by allowing students to upload files in advance, ensuring immediate access to printouts upon QR code scanning. Users receive notifications upon successful item dispensation, providing confirmation of the completed transaction. In essence, our web-based vending machine project offers a modern, efficient, and convenient vending experience for students, integrating user-friendly interfaces, QR code technology, Raspberry Pi processing power, and motorized dispensing mechanisms, while also addressing sustainability and real-time inventory management.

VII. Future scope

In envisioning the future development of our web-based vending machine project, several key directions emerge to further enhance its functionality and user experience. Firstly, there is a plan for the diversification of payment methods, aiming to integrate a broader range of digital payment options to accommodate varying user preferences. This step aligns with the evolving landscape of financial technologies and ensures a seamless and inclusive transaction experience for users. A second direction involves the implementation of machine learning for inventory management. By leveraging historical data and usage patterns, the system aims to optimize inventory levels intelligently, enhancing efficiency and minimizing instances of stockouts or overstock. Security measures are slated for advancement in the project's future. The incorporation of biometric authentication or facial recognition is envisioned to elevate user authentication, ensuring a secure and personalized vending experience. Moreover, the project aims to prioritize user experience by introducing customization features for users and implementing remote monitoring capabilities for administrators. This forward-looking approach seeks to empower users with tailored vending experiences while providing administrators with efficient oversight and management tools. Sustainability and collaboration represent another key direction. The exploration of energy-efficient components reflects a commitment to environmentally conscious practices. Additionally, collaboration with campus systems is envisioned for seamless access and payment integration, fostering a cohesive technological ecosystem.

Looking beyond the immediate scope, the project outlines plan for market expansion and technological evolution. By establishing a foundation for innovative advancements in vending technology, the project aims to position itself as a catalyst for change in the industry. The potential for market expansion beyond educational institutions further underscores the commitment to continuous technological evolution and broader societal impact. In summary, the future directions for our web-based vending machine project encompass a strategic blend of technological advancements, user-centric features, sustainability initiatives, and collaborative endeavors for a more robust and forward-thinking vending experience.

VIII. RESULT

Analyzing various facets, including technology, user interaction, security, and adaptability, the project demonstrates noteworthy strengths. Prioritizing a user-friendly interface and QR code scanning with smartphones or dedicated scanners enhances the overall user experience, contrasting sharply with the limited interfaces of traditional machines. Furthermore, robust security measures, such as QR code validation and encryption, set a high standard for security, a feature lacking in conventional vending machines. The integration of Raspberry Pi and Flask Framework as the project's hardware and software backbone ensures a cohesive system for efficient product dispensing, addressing potential operational inefficiencies found in traditional vending machines. With an emphasis on digitalized payment options, reduced human intervention for inventory updates, and the introduction of a document printing facility, the project stands out for its adaptability, sustainability, and multi-functionality, setting it apart from traditional vending machines limited to dispensing physical products.

IX. CONCLUSION

In conclusion, our web-based vending machine project represents a pioneering leap in vending technology, prioritizing user convenience and technological innovation. With an emphasis on diverse payment options, machine learning-driven inventory optimization, and advanced security measures, the project aims to redefine the vending experience. The commitment to enhanced user functionality, sustainability, and collaboration with campus systems positions it as a forward-thinking solution. By laying the groundwork for market expansion and technological evolution, our project signifies a transformative contribution to the future of vending.

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