International Journal of Multidisciplinary Engineering in Current Research - IJMEC

Volume 11, Issue 7, July-2026, http://ijmec.com/, ISSN: 2456-4265

Design And Implementation of Smart Vending Machine

Ms. Shafia Tasneem[1], P. Dharani[2], T. Navya[3], P. Akhila[4]

[1]Assistant Professor: Department of Electronics and Communication Engineering, Bhoj Reddy Engineering College for Women Hyderabad, India

[2,3,4]B. Tech Students: Department of Electronics and Communication Engineering, Bhoj Reddy Engineering College for Women Hyderabad, India

Mail Id: pallapudharani19@gmail.com[2], navyathalandi@gmail.com[3], akhilapothulapally0@gmail.com[4]

Accepted 4 July 2026

Abstract

An RFID configured vending machine is a smart automated system that uses Radio Frequency Identification (RFID) technology to enable cashless and secure transactions. Unlike conventional vending machines that rely on coins or paper currency, this system identifies users through an RFID card or tag containing a unique identification number. When the RFID card is placed near the RFID reader, radio frequency signals are used to wirelessly read the stored information.

The retrieved data is transmitted to a microcontroller or processing unit, which verifies the user's identity and checks the available balance stored in the system database. If sufficient balance is available, the machine allows the user to select a product using push buttons or a keypad. Once the selection is confirmed, the controller activates the dispensing mechanism, typically operated by a servo motor, to deliver the selected item. After successful dispensing, the system automatically deducts the corresponding amount from the user's balance and updates the database. The entire transaction is completed quickly and efficiently without the need for manual cash handling.

RFID-configured vending machines improve security, reduce transaction time, minimize maintenance issues associated with cash handling, and provide better inventory management. Owing to these advantages, they are widely used in educational institutions, offices, hospitals, and other public places where fast, secure, and reliable service is essential. This work presents the implementation of a Radio Frequency Identification (RFID)-based multiproduct vending machine designed to automatically dispense beverages such as coke, malt, and yogurt using an RFID prepaid payment system. After carefully analyzing the limitations of the existing vending system, a new design was developed to overcome its shortcomings.

The proposed system was implemented using an Arduino Mega microcontroller, an RFID reader and RFID cards, a servo motor, a Liquid Crystal Display (LCD), and other supporting electronic components. A prototyping methodology was adopted, where both hardware and software modules were designed, tested individually, and then integrated to form the complete system. The embedded software was developed using the C programming language to coordinate the operation of all hardware components effectively. Customers can purchase products by swiping their RFID cards across the RFID reader, after which the embedded system authenticates the card, deducts the product cost from the stored balance, dispenses the selected product, and displays the remaining balance on the LCD. The developed system provides a secure, efficient, and user-friendly cashless vending solution suitable for modern automated retail applications.

Keywords— *Radio Frequency Identification (RFID), Vending Machine, Arduino Mega, Cashless Payment System, RFID Reader, Servo Motor, Embedded System, Microcontroller, Liquid Crystal Display (LCD), Product Dispensing, Automation, C Programming.*

Introduction

A vending machine is an automated device that dispenses products such as snacks, beverages, and other items after receiving payment. Traditionally, vending machines operate using coins, paper currency, or payment cards. Their primary function is to provide products quickly and conveniently without requiring human assistance. However, conventional cash-based vending machines often experience problems such as coin jams, note recognition failures, full coin boxes, and product dispensing errors, which reduce efficiency and increase maintenance requirements.

To overcome these limitations, cashless payment technologies have been introduced into vending systems. Among them, **Radio Frequency Identification (RFID)** has emerged as a secure, fast, and reliable solution. RFID technology enables users to make purchases by simply placing an RFID card or tag near an RFID reader. The system authenticates the user, verifies the available balance, dispenses the

selected product, deducts the corresponding amount, and updates the remaining balance automatically. This eliminates the need for coins or paper currency, reducing transaction time and minimizing payment-related issues.

RFID technology was initially developed for military identification systems during World War II and has since evolved into a widely adopted technology for applications such as access control, toll collection, inventory management, electronic payment systems, and asset tracking. Its reliability and contactless operation make it well suited for modern vending machine applications.

Literature Survey

Radio Frequency Identification (RFID) has become one of the most widely used technologies for automatic identification and data capture in modern applications. Before RFID, barcodes were the primary method used for identifying products. Although barcodes are inexpensive and widely adopted, they require direct line-of-sight scanning and can only be read one item at a time, making them less efficient in automated systems.

RFID technology was developed to overcome these limitations by using radio waves to identify and track objects equipped with RFID tags. An RFID tag consists of a small microchip and an antenna that wirelessly transmit stored information to an RFID reader. Unlike barcodes, RFID tags do not require line-of-sight alignment and can be read quickly and accurately, making them suitable for applications such as inventory management, access control, transportation, healthcare, and cashless payment systems.

One of the major advantages of RFID is its ability to provide **unique identification** for each tagged object. While a barcode identifies only the product type, an RFID tag stores a unique serial number that distinguishes one item from another. Another important advantage is **automation**, as RFID readers can detect multiple tags simultaneously without manual intervention, significantly improving operational efficiency (Juels, 2005).

RFID systems are classified into **passive** and **active** tags. Passive RFID tags operate without an internal power source and receive energy from the electromagnetic field generated by the RFID reader, making them cost-effective and suitable for applications such as vending machines and access control. Active RFID tags contain an internal battery, allowing them to communicate over longer distances.

In RFID-based vending machines, the technology enables secure and cashless transactions by authenticating users through RFID cards. After successful verification, the system checks the available balance, dispenses the selected product, deducts the corresponding amount, and updates the user account automatically. Compared with conventional cash-based vending machines, RFID-based systems offer faster transactions, improved security, reduced maintenance, and better sales tracking, making them an effective solution for modern automated vending applications.

Design and Implementation of Smart Vending Machine

Existing System

Traditional vending machines dispense products after accepting coins, paper currency, or cards. Although they are convenient, they often face problems such as coin jams, note recognition failures, and high maintenance costs. Existing RFID-based vending machines improve the payment process by replacing cash with contactless RFID cards.

In an RFID-based system, each user is assigned an RFID card containing a unique identification number. When the card is scanned, the system verifies the user's identity and balance before allowing product selection. The controller then dispenses the selected product and updates the user's balance automatically.

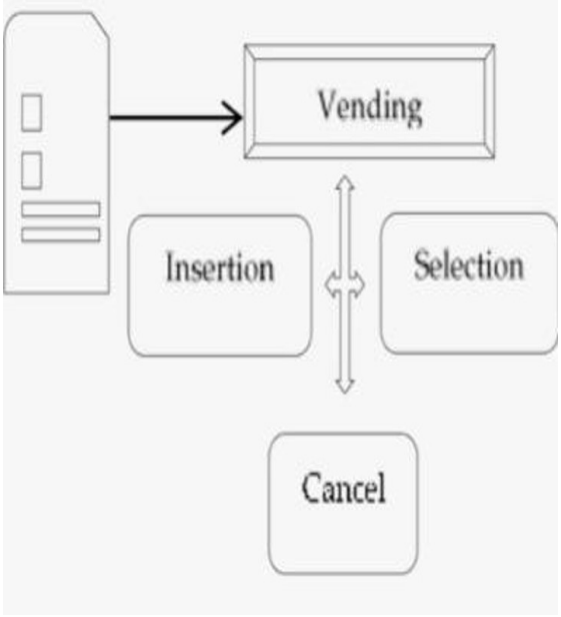

Figure 1; Basic Operation of Vending Machine

Proposed System

The proposed Smart Vending Machine is designed using both hardware and software modules. The system replaces conventional cash payments with RFID-based authentication, providing a secure and convenient cashless payment method.

The hardware consists of an **Arduino Mega**, RFID reader, RFID cards, LCD display, keypad/push buttons, servo motor, potentiometer, IR sensor, buzzer, power supply, and switching circuits. The Arduino Mega acts as the central controller, coordinating all operations including user authentication, product selection, balance verification, and product dispensing. The embedded software is developed in C/C++ using the Arduino IDE.

Block Diagram

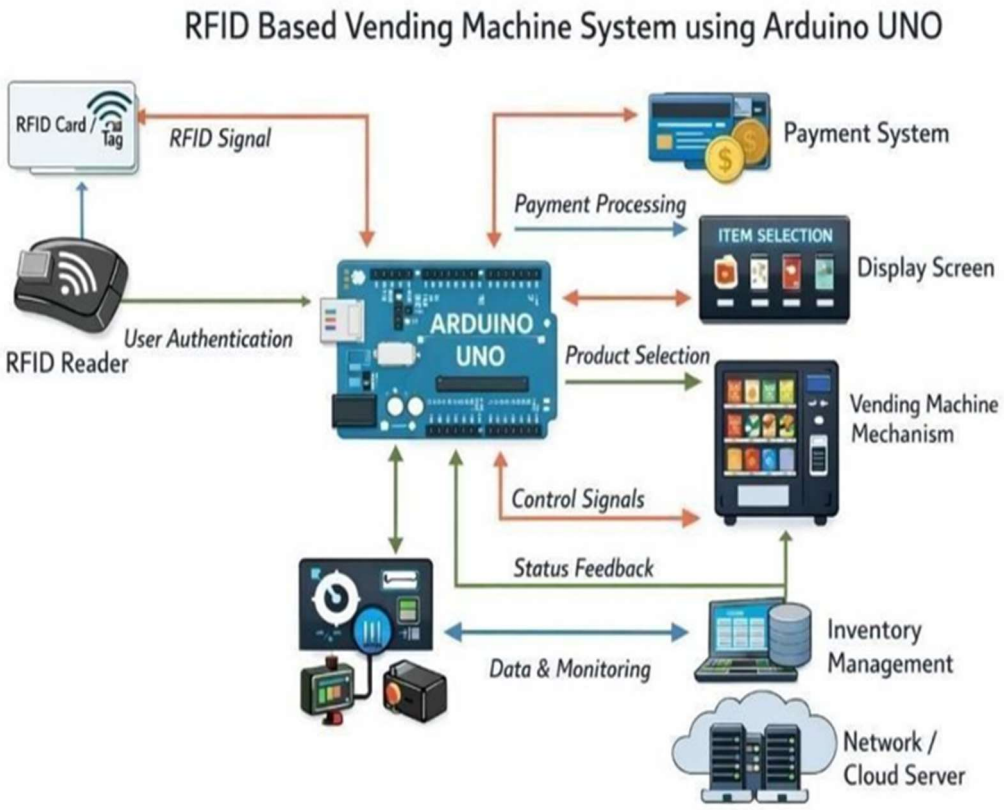

Figure 2; Block Diagram of Smart Vending Machine

The operation of the Smart Vending Machine begins when the user places an RFID card near the RFID reader. The reader detects the card and reads its unique identification number, which is then transmitted to the Arduino Mega microcontroller. The controller verifies the authenticity of the card and checks whether sufficient balance is available in the user's account. If the authentication is successful, the LCD displays the list of available products. The user then selects the desired product using push buttons or a keypad. After confirming the selection, the system deducts the corresponding product cost from the user's balance. The Arduino Mega activates the servo motor, which dispenses the selected product. Finally, the updated account balance is displayed on the LCD, and the system returns to the idle state, ready to process the next customer's transaction.

Working

The Smart Vending Machine operates through RFID-based authentication and an automated product dispensing mechanism. Initially, the system remains in standby mode, waiting for the user to scan an RFID card. Once the card is detected, the RFID reader reads the unique identification number and sends it to the Arduino Mega microcontroller for authentication. The controller verifies the card details and checks whether the user has sufficient balance to make a purchase. If the authentication is successful, the LCD displays the available products, allowing the user to select the desired item using push buttons or a keypad. After the product is selected, the controller deducts the corresponding amount from the user's balance and activates the servo motor to dispense the selected product. Once the dispensing process is completed, the remaining balance is displayed on the LCD. If the card is invalid or the available balance is insufficient, the system displays an appropriate error message and cancels the transaction. After every successful or

unsuccessful transaction, the system automatically resets to the idle state and waits for the next user.

Methodology

The proposed Smart Vending Machine is developed using a modular design approach that integrates both hardware and software components to provide an efficient cashless vending solution. The hardware consists of an Arduino Mega microcontroller, RFID reader, RFID cards, LCD display, servo motor, push buttons, buzzer, IR sensor, and power supply. The software is developed using Embedded C/C++ in the Arduino IDE, enabling communication and coordination among all hardware modules. The system first performs RFID authentication by reading the user's RFID card and verifying its unique identification number. After successful authentication, the available balance is checked to ensure sufficient funds for the selected product. The user then selects the desired product through push buttons or a keypad, and the system processes the payment by deducting the product cost from the stored balance. The Arduino Mega subsequently controls the servo motor to dispense the selected product. Finally, the LCD updates the transaction status and displays the remaining balance before the system automatically resets to its standby mode, ready to serve the next customer. This modular methodology ensures reliable operation, secure transactions, easy maintenance, and efficient product dispensing.

Results and Discussion

1. System Architecture and Components

The developed Smart Vending Machine consists of an Arduino Mega microcontroller, RFID reader (MFRC522), RFID cards, LCD display, servo motor, push buttons, buzzer, IR sensor, and power supply. The Arduino Mega serves as the central controller, processing user authentication, product selection, balance verification, and product dispensing. The hardware modules work together efficiently to provide reliable vending operations.

2. RFID Technology Integration

The RFID module successfully performs contactless authentication by reading the unique identification number stored in the RFID card. When the user places the card near the RFID reader, the system instantly verifies the card and authorizes the transaction. This eliminates the need for cash handling and significantly reduces transaction time while improving convenience.

3. User Authentication and Security

The system authenticates users by comparing the scanned RFID card ID with the registered IDs stored in the controller. Only authorized users are allowed to purchase products. Invalid or unauthorized RFID cards are rejected, ensuring secure system operation and preventing unauthorized access.

4. Cashless Transaction System

The vending machine operates using a prepaid RFID payment mechanism. After successful authentication, the system checks the available balance stored for the user. If sufficient balance is available, the product cost is automatically deducted after dispensing. This cashless approach minimizes transaction errors and provides a faster purchasing experience.

5. Product Selection and Dispensing

After authentication, the available products are displayed on the LCD. The user selects the desired product using push buttons or a keypad. The Arduino Mega processes the request and activates the servo motor to dispense the selected item accurately. The dispensing mechanism operates smoothly and reliably for each successful transaction.

6. LCD Display and User Interface

The LCD display provides clear information throughout the transaction process, including authentication status, available products, product price, remaining balance, and transaction completion messages. The simple user interface makes the vending machine easy to operate for all users.

7. Balance Management

The system maintains the balance associated with each RFID card. After every successful purchase, the corresponding amount is deducted automatically, and the updated balance is displayed on the LCD. This ensures accurate transaction records and efficient balance management.

8. Power Management

A regulated power supply provides stable voltage to the Arduino Mega, RFID reader, LCD, and servo motor. Proper power management ensures uninterrupted system operation and protects the electronic components from voltage fluctuations.

9. Scalability and Future Enhancement

The proposed system can be easily expanded by integrating Wi-Fi, GSM, or IoT modules for remote monitoring, online balance management, inventory tracking, and sales analysis. Additional product slots and digital payment methods can also be incorporated without major hardware modifications.

10. Reliability and Performance

Experimental testing confirms that the RFID-based Smart Vending Machine performs accurately and consistently. The system provides fast RFID authentication, reliable product dispensing, secure cashless transactions, and low maintenance compared to conventional coin-operated vending machines. The overall implementation demonstrates improved

efficiency, enhanced security, and better user convenience.

Result

The developed Smart Vending Machine was successfully implemented and tested under different operating conditions. The RFID reader accurately detected authorized RFID cards, and the Arduino Mega verified user authentication before permitting product selection. Upon selecting a product, the system automatically deducted the corresponding amount from the stored balance and activated the servo motor to dispense the selected item. The LCD continuously displayed authentication status, product information, transaction confirmation, and the remaining balance, providing a clear and user-friendly interface. The experimental results confirm that the proposed system offers reliable operation, secure cashless transactions, accurate product dispensing, and efficient performance suitable for educational institutions, offices, hospitals, and other public environments.

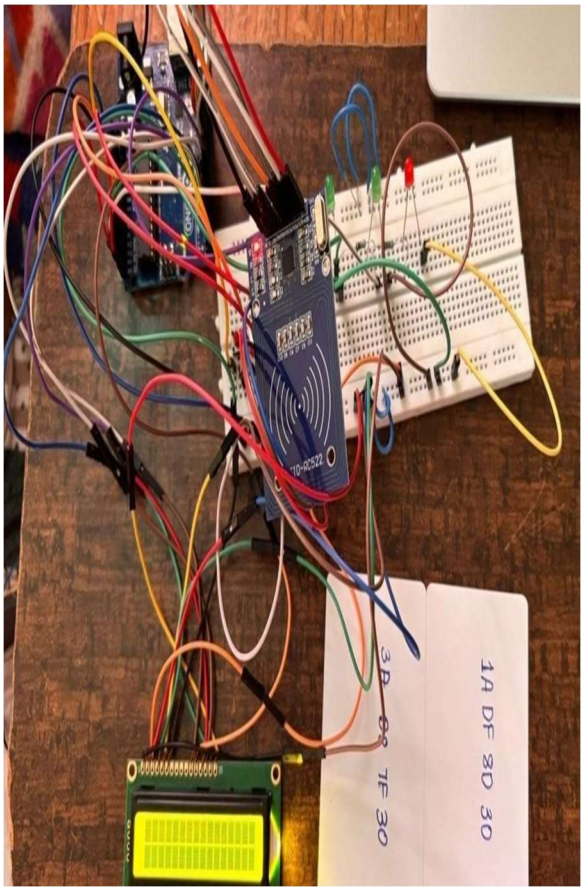

Figure 3; Result of Smart Vending Machine

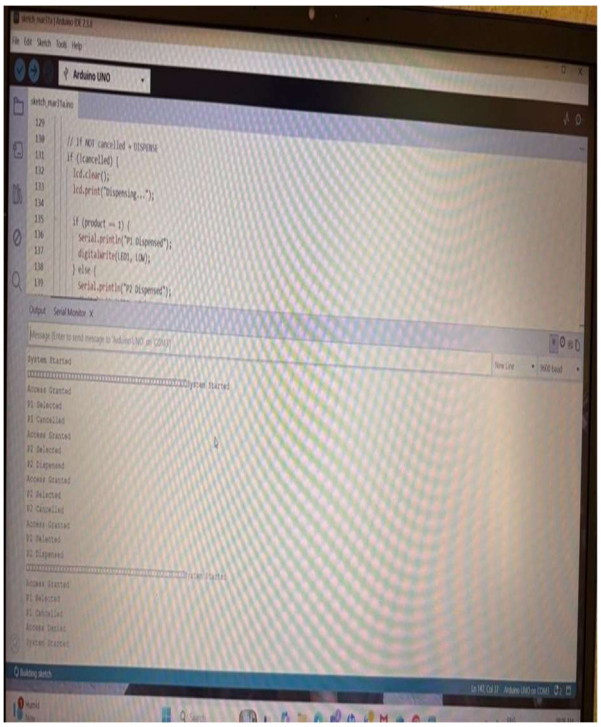

Figure 4; Arduino IDE Serial Monitor Output

Conclusion and Future Scope

Conclusion

The RFID-configured Smart Vending Machine developed using the Arduino Mega provides an efficient, secure, and automated solution for cashless product dispensing. By integrating RFID technology with an embedded control system, the machine eliminates the need for cash transactions, reduces manual intervention, and enables quick user authentication and accurate billing. The system offers a simple and user-friendly interface, making the purchasing process fast and convenient.

This project demonstrates that low-cost hardware components such as the Arduino Mega, RFID reader, LCD display, servo motor, and push buttons can be effectively integrated to develop a reliable smart vending system. The proposed system minimizes transaction time, reduces payment errors, improves security, and provides accurate balance management compared to conventional cash-based vending machines.

The implementation also confirms that RFID cards can be successfully used for secure user identification and prepaid balance management. The Arduino Mega efficiently coordinates communication between the RFID reader, display unit, and dispensing mechanism to ensure smooth system operation. Overall, the developed Smart Vending Machine is reliable, scalable, cost-effective, and well suited for

deployment in educational institutions, offices, hospitals, and other public places requiring automated retail services.

Future Scope

The RFID-configured Smart Vending Machine has considerable potential for future enhancements due to rapid developments in automation, digital payments, and smart technologies. Future versions of the system can incorporate Internet of Things (IoT) technology to enable real-time monitoring of inventory, machine health, sales reports, and transaction history through web-based dashboards or mobile applications. This will allow operators to remotely monitor and manage multiple vending machines efficiently.

The system can also be upgraded by supporting additional cashless payment methods such as UPI, QR code payments, debit/credit cards, NFC, and mobile wallets, reducing dependency on RFID cards and providing greater convenience for users. Security can be further enhanced by integrating biometric authentication methods such as fingerprint or facial recognition for user verification.

Artificial Intelligence and Machine Learning techniques can be incorporated to analyze customer purchasing behavior, recommend products, predict demand, and optimize inventory management. Cloud-based databases can securely store transaction records and enable centralized monitoring across multiple vending machines. Smart inventory management systems can automatically detect low stock levels and generate restocking alerts, reducing manual maintenance.

Future designs may also adopt energy-efficient technologies such as solar-powered operation and low-power electronic components for deployment in outdoor and remote locations. Advanced microcontrollers such as the **ESP32** can replace the Arduino Mega to provide built-in Wi-Fi and Bluetooth connectivity for seamless communication. With these enhancements, the Smart Vending Machine can become a fully automated, intelligent, secure, and scalable solution suitable for smart campuses, offices, transportation hubs, hospitals, shopping malls, and smart city applications.

References

[1] S. S. T. T. M. B. P. M. Sravan Kumar, "Medicine Vending Machine," International Research Journal of Engineering and Technology (IRJET), vol. 7, no. 6, June 2020.

[2] TCN Vending Machine, "Main Application of Vending Machine." [Online]. Available: http://www.tcnvend.com/main-application-of-vending-machine-182.html

[3] A. Alushi, "Development of Vending Machine with Prepaid Payment Method," 2008. [Online]. Available: http://umpir.ump.edu.my/id/eprint/193/3/Development%20of%20vending%20machine%20with%20prepaid%20payment%20method%20-%20Chapter%201.pdf

[4] M. L. Kasavana, "V-Commerce: Vending Machine Technology," vol. 21, no. 1, January 2003.

[5] StrategyR, "Vending Machines – Global Market Trajectory & Analytics." [Online]. Available: https://www.strategyr.com/market-report-vending-machines-forecasts-global-industry-analysts-inc.asp

[6] M. A. DT Wiyanti, "Automated Vending Machine with IoT Infrastructure for Smart Factory Application," in International Conference on Mathematics, Science, and Education, 2019.

[7] "New Technologies Are Revolutionising the World of Vending Machines – For the Better," 2020.

[8] B. P. and B. Singh, "Design and Development of Vending Machine Using AVR ATmega8515 Microcontroller," International Journal of Advanced Research in Computer Science, vol. 3, no. 3, May–June 2012.

[9] M. K. N. K. D. G. S. G. K. D. Amrita Soni, "Arduino Based Reverse Vending Machine," International Research Journal of Engineering and Technology (IRJET), vol. 7, no. 8, August 2020.

[10] B. S. Ana Monga, "Finite State Machine Based Vending Machine Controller with Auto-Billing Features," International Journal of VLSI Design & Communication Systems, vol. 3, no. 2, April 2012.