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IoT-Based Sanitary Pad Vending Machine with QR-Code Payment and Real-Time Inventory Monitoring

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Abstract—Access to menstrual hygiene products can be improved through convenient, discreet, and reliable dispensing systems. This paper presents an Internet of Things (IoT)-based sanitary pad vending machine described in the source project report. The proposed system combines an ESP32 microcontroller, QR-code-based user/payment flow, MQTT communication with an Adafruit IO dashboard, infrared (IR) sensors for product-presence and dispensing checks, a motor-driven dispensing mechanism, and LCD/LED/buzzer feedback. The controller checks product availability before operating the dispensing motor and updates stock information for remote monitoring. The report describes the system architecture, operating workflow, hardware/software integration, and implementation challenges. The design aims to reduce manual stock checking and make product access more convenient. The source report does not provide a complete quantitative test dataset; therefore, this paper describes the design and reported functionality without claiming measured performance improvements.

Keywords—Internet of Things, sanitary pad vending machine, ESP32, QR code, MQTT, infrared sensor, inventory monitoring, automated dispensing.

I. INTRODUCTION

Menstrual hygiene products should be available in public spaces and various institutions in a way that is accessible, discreet, and reliable. Traditional vending machines may require manual oversight and periodic stock checks. The project described in the attached report presents an IoT-based vending machine for menstrual hygiene products, designed to automate product dispensing and report stock status to a connected control panel. [1]

The design combines onboard control with wireless communication. An ESP32 coordinates the workflow—including QR codes and payments—as well as sensor management, motor control, user notifications, and inventory updates. The MQTT protocol is used for communication with the Adafruit IO platform, while an LCD screen and LED indicators provide local status information. The system is designed to facilitate both direct customer interaction and remote monitoring by operators. [2]

The primary objective of this project is to develop a practical, automated dispensing system for menstrual hygiene products that integrates secure digital payments and real-time remote monitoring. To ensure accessibility and reliable operation, the device utilizes a QR code scanning mechanism combined with an automated workflow that verifies payment before dispensing. The hardware incorporates a set of infrared (IR) sensors to continuously monitor inventory levels, preventing unnecessary dispensing attempts when products are out of stock. User interaction and system diagnostics are managed via an LCD screen that displays real-time status, supplemented by visual LED indicators and an audible signal for alerts—such as power-on status, operational updates, and

low-stock warnings. Furthermore, the system includes Wi-Fi connectivity to transmit critical inventory and operational data to a centralized IoT dashboard, enabling continuous remote monitoring and inventory management. [3]

This document describes the architecture and workflow presented in the report. The source is a scanned project document; certain technical details and the bibliography are not sufficiently legible to verify the exact component numbers, implementation code, or values measured during testing. These details have not been included in this document.[4]

The system is based on an ESP32 controller connected to subsystems for detection, dispensing, display, power, and networking. A QR code and a payment interface initiate the order. The controller verifies the payment status and product availability, activates the appropriate DC motor once the order is approved, monitors the dispensing process via infrared sensors, and provides updates to the user while also updating the inventory status.[5]The hardware architecture of the proposed system centres on an ESP32 microcontroller, which serves as the primary processing unit and is responsible for sensor evaluation, motor control, wireless communication, and IoT data transmission. The physical dispensing process is driven by DC motors coupled with an actuator mechanism that releases items from their designated storage compartments. To manage inventory integrity, infrared (IR) sensors are integrated to continuously monitor product availability within the machine and confirm that the dispensing action has been successfully completed. System status and step-by-step user instructions—such as payment validation, the progress of a dispensing operation, and out-of-stock alerts—are communicated visually via a 16x2 LCD screen, supplemented by color-coded LED indicators and an audible signal (buzzer) that provides immediate feedback regarding errors or operational issues. Network connectivity and user interaction are handled through an integrated Wi-Fi interface, enabling payment validation via QR codes and the continuous transmission of telemetry to a remote IoT dashboard. The system also incorporates a switched-mode power supply (SMPS) to ensure a stable power supply to all electronic components. [6]

It also illustrates the wiring and integration of components. The exact pin assignments must be verified against the final schematic and firmware before replicating the design.

The ESP32 firmware is described as being responsible for coordinating the system state and interacting with the hardware. The report identifies the Arduino development environment, Wi-Fi connectivity, MQTT messaging, and Adafruit IO as components of the software stack. In the described configuration, the microcontroller publishes or receives status information via configured data streams, including data related to payments and inventory. The control panel enables remote monitoring of inventory and machine status.[7-8]

IV. METHODOLOGY

The operating sequence of the dispensing system begins with an initialization phase, during which the ESP32 microcontroller powers on, configures the connected devices, and establishes a connection to the local Wi-Fi network and the designated IoT platform. To initiate a transaction, the user scans the displayed QR code, triggering a payment verification process in which the controller validates the transaction status via an MQTT-based messaging flow. Dispensing proceeds only upon explicit confirmation of payment. Once payment is confirmed, the system immediately checks the inventory using a set of infrared (IR) sensors to verify product availability in the requested compartment. If the inventory is confirmed, the controller activates the DC motor mechanism to dispense a sanitary pad. The device then evaluates the sensor data received after dispensing to confirm that the product has been delivered correctly, subsequently displaying the transaction results on the LCD screen and via visual indicators. At the end of the cycle, updated inventory data and system telemetry are transmitted to the remote IoT dashboard. Should an incident occur—such as the inventory running out before dispensing, or a malfunction in the dispensing mechanism—the system triggers an exception-handling protocol, displaying an error message on the LCD screen and activating audible and visual alerts via a buzzer and LED error indicators.

The intended sequence links payment authorization, inventory validation, activation, user feedback, and the generation of inventory reports. A robust

implementation requires clear management of timeouts, as well as defined responses to network loss, delays in payment confirmation, and unreliable sensor readings.

The paper describes hardware assembly, the connection of sensors and actuators to the ESP32, firmware uploading via the Arduino IDE, and the configuration of the IoT platform. Integration requires that the motor controller and power supply be appropriate for the motor load, that sensor outputs be compatible with controller inputs, and that the display/indicators accurately reflect the controller's status. Wi-Fi credentials and IoT service flow/key settings must be configured before remote updates can be performed.

The document concerns schematic/simulation work and tests related to QR code scanning, payment validation, motor operation, inventory detection, and IoT communication. However, the material analyzed does not provide a complete and consistently readable test protocol, nor does it offer quantitative results. Consequently, this document makes no claims regarding numerical accuracy, latency, reliability, or performance.

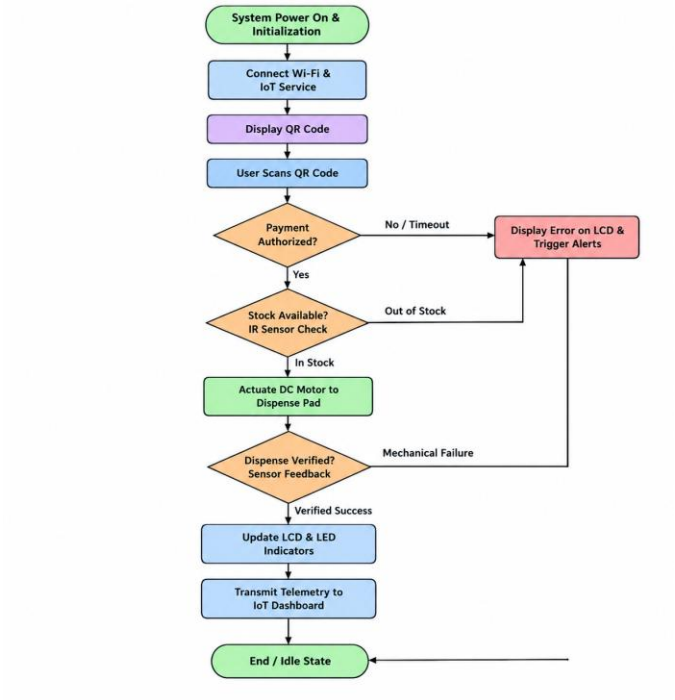


Figure 1. Operational Workflow

VI. RESULT AND DISCUSSION

The integrated design offers several intended advantages. Automated dispensing reduces the need for an employee to be present for every transaction. QR code-based payment enables contactless interaction, while on-device notifications via LCD and LED screens help the user understand the current status. Remote inventory reporting facilitates restocking decisions, as opposed to relying solely on periodic manual inspections.

Functionality relies on the collaboration of multiple subsystems. Network interruptions can disrupt payment status verification or control panel updates. A sensor may fail to detect a product correctly, and a motor might stall or dispense an item improperly. Payment events must be validated against the status of a trusted server, rather than relying solely on a message from the client. Credentials and API keys must be secured, and payment communications must employ appropriate access controls and secure transport mechanisms. The original report identifies network dependencies and hardware/sensor issues as implementation challenges, but it does not document a comprehensive security assessment.

The source material consists of a scanned project report, in which certain pages—notably the reference list and parts of the diagrams—are difficult to read. Consequently, this document focuses on the design and functionality explicitly described in the report. It should be viewed more as a design-oriented project than as a validated experimental study. Before formal submission, the authors should verify the exact circuit, source code, test data, and bibliographic references.

To enhance the system's functionality and operational stability, several areas for research and technical refinement have been identified. Security can be strengthened by integrating robust authentication protocols—such as two-factor authentication—to better protect digital transactions. To optimize supply chain efficiency, the integration of machine learning models, trained on historical usage patterns, would enable predictive inventory management and automated replenishment scheduling. Reliability can be further improved by refining sensor diagnostics to accurately distinguish between depleted inventory, mechanical dispensing failures, and individual sensor malfunctions. To mitigate potential connectivity disruptions, implementing local state logging, combined with robust retry mechanisms, will allow the system to maintain stable operation offline during Wi-Fi or cloud outages. Furthermore,

refining the physical user interface and interaction workflows will improve overall accessibility throughout the sales process. Finally, future work will focus on comprehensive empirical evaluation using standardized test metrics—assessing QR code recognition rates, payment verification latency, dispensing success rates, inventory tracking accuracy, and recovery performance in the event of network failures.

These are proposed development directions; the report does not establish that all of them have been implemented.

VIII. CONCLUSION

This document presents the design of an Internet of Things (IoT)-based vending machine for sanitary pads, as described in the accompanying project report. The proposed system utilizes an ESP32 microcontroller, a QR code-based workflow and payment system, infrared sensors, a motorized dispensing mechanism, an LCD screen, LED and buzzer indicators, and MQTT communication with a control dashboard on Adafruit IO. Its primary objective is to combine automated product delivery with remote inventory monitoring and clear user communication. Although the architecture shows promise as a prototype concept, its practical implementation requires a verified payment processing system, secure configuration, robust error handling, and rigorous validation of the accuracy of both the dispensing and inventory control functions. A thorough experimental evaluation and a verified list of references are necessary before any quantitative performance claims can be made or the work can be presented as a fully validated system.

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