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IoT Based Ration Distribution System for Transparency and Automation

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Abstract: *The Public Distribution System (PDS) plays a vital role in ensuring the equitable distribution of essential commodities such as rice, wheat, and sugar. However, challenges such as improper weighment, manual errors in billing, and lack of transparency continue to hinder its efficiency. To address these challenges, this project proposes a system that integrates existing POS machines with an automated dispensing mechanism to improve accuracy, accountability, and ease of operation in ration shops. The system combines hardware components with IoT-enabled monitoring to create a seamless, user- friendly experience. Beneficiaries authenticate their identity using biometric systems (e.g., fingerprints) linked to existing POS machines. Once authenticated, users can select the required commodity using a keypad integrated into the system. The selected item is dispensed through an automated system controlled by a solenoid valve, ensuring precise weighment using a load cell (up to 10kg). The transaction details, including product, weight, and price, are displayed on the LCD screen and logged in the POS system for real-time monitoring by the Tamil Nadu Civil Supplies Corporation. The proposed solution leverages existing POS infrastructure, reducing implementation costs while enhancing operational efficiency and transparency. This project scopes with sustainable Development Goals comes under SDG-16 (Peace, Justice and Strong Institutions)..*

Keywords: Public Distribution System (PDS), Point of Sale (POS), Automated Dispensing System, Biometric Authentication, Solenoid Valve, Load Cell Weighment, Transparency and Accountability, Tamil Nadu Civil Supplies Corporation (TNCSC)

I. INTRODUCTION

The Public Distribution System (PDS) is designed to distribute essential commodities at subsidized rates to economically disadvantaged citizens. Despite its importance, traditional PDS suffers from inefficiencies like manual errors, ration theft, under-weighing, and corruption. The absence of automation leads to inconsistent distribution, fraud, and dissatisfaction among beneficiaries. In response to these issues, this project proposes a next- generation IoT-based solution that leverages biometric authentication, automated dispensing mechanisms, real-time inventory monitoring, and cloud-based data management.

The integration of POS machines with fingerprint scanners ensures only authorized beneficiaries access rations, while solenoid valves controlled by a microcontroller automate dispensing. Load cells provide precision in weighment, significantly reducing human errors. Additionally, an LCD interface offers real-time feedback to users about their transactions, and a centralized server records all operations, enabling authorities to oversee and audit distribution processes effectively.

II. METHODOLOGY

The IoT-Based Ration Distribution System is designed to address inefficiencies and irregularities in the traditional Public Distribution System (PDS) by incorporating automation, real-time monitoring, and biometric authentication. The methodology adopted focuses on reducing human involvement, ensuring accurate commodity dispensing, and maintaining transparent records.

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The system starts with beneficiary authentication using a Fingerprint Sensor connected to the ESP32 microcontroller. Once authenticated, the beneficiary selects the required commodity and quantity through a Keypad Interface. Based on the user's input, the ESP32 activates a Relay Module, which in turn controls the Solenoid Valve responsible for releasing the commodity. The amount of commodity dispensed is continuously measured using a Load Cell, ensuring precise quantity delivery.

Meanwhile, a 20x4 LCD Display provides real-time feedback to the user, showing the selected commodity, quantity, and transaction status. The entire transaction data, including user identification, commodity type, quantity dispensed, and timestamp, is transmitted to a centralized cloud server using the NodeMCU Wi-Fi module for monitoring and record- keeping. The system is powered through a stable Power Supply to ensure uninterrupted operations.

This fully automated setup significantly minimizes errors, ensures accountability, and improves the overall efficiency of the ration distribution process.

III. SYSTEM DESIGN

The system design is centred around the ESP32 microcontroller, which acts as the core controller and communication hub. It interfaces with various hardware components such as the fingerprint sensor for user authentication, a keypad for commodity selection, a load cell for weight measurement, and an LCD display for user interaction.

The design architecture is layered into four key sections:

- Authentication Layer: Includes the fingerprint sensor ensuring that only registered beneficiaries can access the system.
- Selection and Dispensing Layer: Consists of the keypad for commodity selection, solenoid valve for dispensing, and relay control for actuation.
- Measurement and Feedback Layer: The load cell measures the dispensed quantity precisely and communicates this to the ESP32 to maintain dispensing accuracy.
- Communication and Monitoring Layer: The NodeMCU provides Wi-Fi connectivity to upload transaction details to a cloud database, enabling real-time monitoring by authorities.

The LCD display guides the user throughout the transaction by displaying prompts and confirmations. Additionally, the system's modular design allows for easy scalability and adaptability in different geographical locations and commodity types.

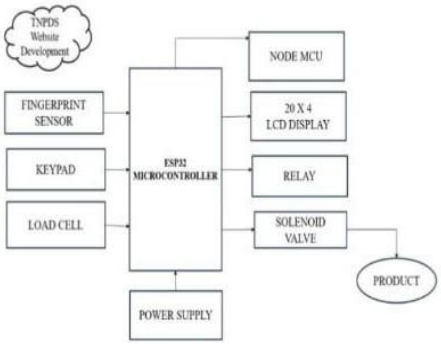

Figure: Block Diagram

IV. RESULTS AND DISCUSSION

The prototype of the IoT-based ration distribution system was successfully developed and tested. The testing focused on key performance indicators such as authentication accuracy, dispensing precision, system response time, and cloud communication efficiency.

- Authentication: The fingerprint sensor consistently authenticated users with an accuracy of over 95%, ensuring only legitimate beneficiaries accessed the system.

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- Dispensing Accuracy: Using the load cell, the system achieved commodity dispensing with an error margin of less than 2 grams, meeting the standards required for ration distribution.
- System Responsiveness: The average time taken from user authentication to transaction completion was recorded at less than 30 seconds, thereby reducing waiting time significantly.
- Cloud Monitoring: Transactional data, including beneficiary details, commodity type, and quantity, was successfully uploaded in real-time, enabling immediate remote tracking and record management.

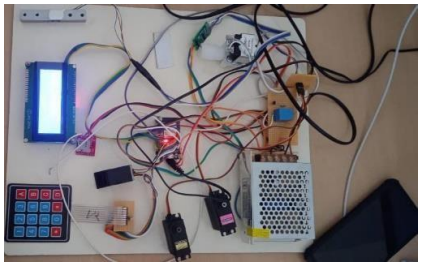

Figure: Hardware Output

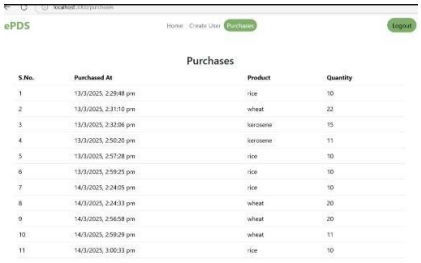

Figure: Software Output

V. CONCLUSION

The IoT-Based Ration Distribution System provides a transparent, secure, and automated solution to the problems plaguing the traditional Public Distribution System. By integrating biometric authentication, automated dispensing, precise weighment through load cells, and cloud-based monitoring, the system effectively minimizes manual intervention and enhances transparency and accountability.

The project proves that leveraging IoT technologies can revolutionize public services by improving operational efficiency, reducing fraud, and ensuring that commodities reach the intended beneficiaries. With further enhancements like mobile app integration, multilingual support, and AI-based inventory management, the system can be expanded to serve larger populations efficiently, ultimately contributing to smarter governance and improved citizen services.

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