IOT-Based Grain Dispenser Machine

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***Abstract*—The public distribution system (PDS) in government ration stores plays a vital role in ensuring food security for economically weaker sections of society. However, the traditional grain distribution process in ration stores often faces challenges such as manual errors, grain pilferage, lack of transparency, and inefficient inventory management. This research presents the development of an IoT-based grain dispenser system designed specifically for government ration shops to automate and secure the grain distribution process. The proposed system integrates weight sensors, smart controllers, RFID/Aadhaar-based user authentication, and cloud connectivity to ensure accurate, tamper-proof, and transparent delivery of subsidized grains. Beneficiaries can authenticate themselves, select grain types, and receive precise quantities automatically, while real-time data on grain levels and distribution logs are uploaded to a centralized monitoring system. This not only improves efficiency and accountability but also helps prevent corruption and leakage in the PDS network. The paper details the design architecture, working model, and potential socio-economic impact of implementing such a system in public distribution channels.**

***Index Terms*—IoT, Grain Dispenser, Public Distribution System (PDS), RFID, Load Cell, GSM Module, ESP8266, Atmega328, QR Payment**

I. INTRODUCTION

The Public Distribution System (PDS) is a critical component of India's welfare infrastructure, responsible for delivering subsidized food grains to millions of Below Poverty Line (BPL) families. Despite its scale and intent, the current manual system is plagued with major inefficiencies, including grain theft, black marketing, improper weighing, duplicate ration cards, and long queues. These issues result in dissatisfaction among beneficiaries and substantial financial loss to the government.

In response to these challenges, this research proposes an IoT-based automated grain dispenser designed specifically for government ration shops. The system introduces automation, digital user verification, and real-time monitoring to improve accuracy, security, and transparency in the grain distribution process.

The core of the system is the ATmega328P micro-controller, selected for its low cost, versatility, and ease of programming. It manages the operations of peripheral devices such as:

- RFID module for secure identification of ration card holders.
- QR code scanner to enable Aadhaar or digital ration card scanning.
- Keypad and LCD display for user input and feedback.
- DC gear motor and relay driver module for grain dispensing mechanism.
- Load cell for accurate real-time measurement of dispensed grain.
- ESP8266 Wi-Fi module to connect the system to a cloud server for remote monitoring and control.
- GSM modem to provide SMS notifications to users and alerts to administrators.

The system ensures that only authenticated users can access their allotted quota. Once verified via RFID or QR code, the user can input the grain type and quantity using the keypad. The load cell continuously measures the grain dispensed, and the DC gear motor

stops automatically when the target quantity is reached. All transaction data is logged and sent to the cloud through the ESP8266, while the GSM module sends SMS confirmations, thereby keeping both users and authorities informed.

This innovation addresses several key concerns in the existing system:

- Reduces manual intervention and eliminates human error.
- Improves trust and transparency through digital logs and alerts.
- Supports real-time monitoring of grain stock and usage across multiple ration shops.
- Promotes Digital India and e-Governance initiatives by bridging the technology gap in rural supply chains.

II. METHODOLOGY

2.1: Block diagram

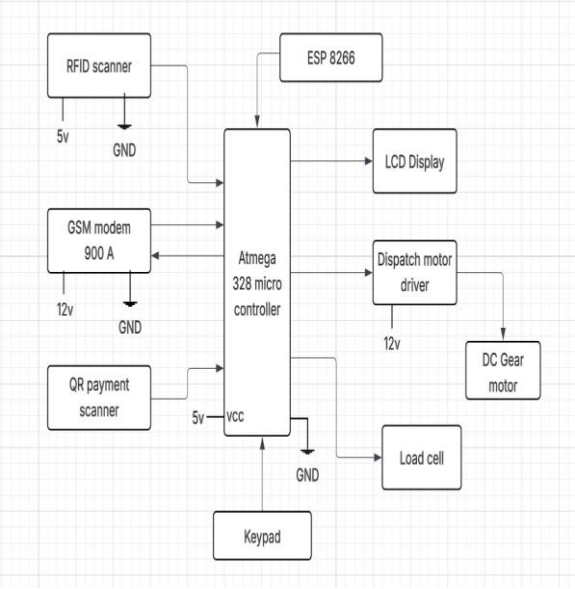

Figure 2.1.1: Block Diagram

2.2: Components and Description

A. Hardware components:

- Atmega328 Microcontroller: Acts as the brain of the system, controlling all sensors and modules.
- RFID Reader: Authenticates users by reading RFID-enabled ration cards.
- GSM 900A Module: Sends SMS alerts to users and administrators.
- Load Cell + HX711 Amplifier: Measures grain weight precisely during dispensing.
- DC Gear Motor: Drives the mechanism to release grains.
- LCD Display (16x2): Displays instructions, weights, and user details.
- QR Code Scanner: Allows users to pay digitally.
- Keypad: Enables manual input if required.
- Relay Module: Controls the motor switching.
- ESP8266 Wi-Fi Module: Facilitates cloud connectivity for future expansion.

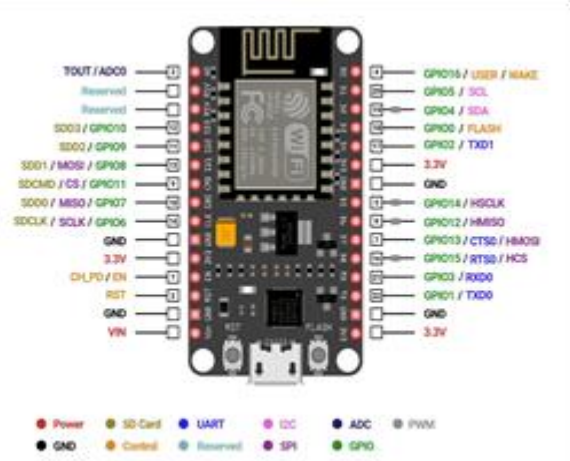

Figure 2.2.1: ESP2866 Pin Diagram

B. Software components:

- Arduino IDE: Used to program the Atmega328 microcontroller.
- Embedded C/C++: The primary programming language used.
- Cloud Platform (optional): Future integration for remote monitoring and data logging.

2.3: Proposed system:

The IoT-based grain dispenser system is designed to automate and secure the distribution of grains using an integrated set of hardware and software components. At its core, the ATmega328P microcontroller functions as the central control unit, managing all input and output operations. User authentication is achieved through an RFID module for ration card verification and a QR code scanner for digital identity validation, such as Aadhaar-linked QR codes, ensuring only authorized users can access the service. For user interaction, a keypad allows selection of grain type and quantity, while an LCD display provides instructions, real-time weight updates, and transaction status. The dispensing mechanism consists of a DC gear motor controlled by a relay driver, with a load cell and HX711 amplifier

measuring grain weight continuously to stop the motor automatically when the desired quantity is reached, thereby ensuring accuracy and minimizing wastage. Communication is facilitated by an ESP8266 Wi-Fi module that uploads transaction details, stock levels, and user data to a cloud server for monitoring, while a GSM module sends SMS notifications to both the user and the administrator. The overall transaction flow begins with system initialization, followed by user authentication, quantity selection, dispensing, automatic stoppage at the target weight, and data logging with communication updates. The system is programmed using the Arduino IDE, and thorough testing is performed to validate authentication reliability, measurement accuracy, dispensing efficiency, and communication stability. This integrated approach not only ensures transparency and accountability but also enhances efficiency and reliability in ration distribution.

III. IMPLEMENTATION

A. Hardware Implementation

The hardware for the IoT-based grain dispenser is designed to ensure accurate measurement, dispensing, and monitoring of grains. The major components used are:

1.MicrocontrollerUnit (MCU):
An Atmega328 is used as the central control unit. It manages sensor readings, motor control, and IoT connectivity.

2.Load Cell with HX711 Module:
A load cell is integrated to measure the weight of grains accurately. The HX711 amplifier module converts the analog signal from the load cell into digital data, which is processed by the microcontroller.

3.Motor and Actuator Mechanism:
DC motor with relay is employed for controlling the gate/valve of the grain container. This ensures precise dispensing according to the required weight.

4.PowerSupply:
A regulated 5V/12V power adapter supplies stable voltage to sensors, motors, and the microcontroller.

5.ConnectivityModule:
The ESP8266 provides Wi-Fi connectivity, enabling data transmission to a cloud platform or mobile application for monitoring and control.

6. Supporting Components:

a. LCD/LED display for local weight readouts.
b. Push buttons for manual calibration and dispensing.
c. Hopper design for uniform grain flow.

B. Software Implementation

The software is developed to integrate sensor readings, control logic, and IoT-based monitoring. The major steps include:

1.Firmware Development:
The microcontroller is programmed using Arduino IDE (C/C++).The code initializes load cell calibration, sets motor control parameters, and manages user input.

2.Control Algorithm:
The load cell continuously measures the weight. When a target weight is entered (via keypad/app), the microcontroller activates the motor to dispense grains.
Once the desired weight is reached, the motor stops automatically. Safety conditions (e.g., motor cutoff in case of overload) are implemented.

3.IoT Integration:
The ESP8266 connects to Wi-Fi and sends real-time data (weight, dispensing status and payment confirmation) to a cloud service like ThingSpeak. A mobile/web interface allows users to remotely monitor stock levels and trigger dispensing operations.

4.User Interface:
A simple mobile app/dashboard displays:
1.Current grain stock.
2.Dispensed weight logs.
3.Alerts for low stock.

5.Data Logging:

The system maintains a record of dispensing cycles, which can be accessed for usage analysis and inventory management.

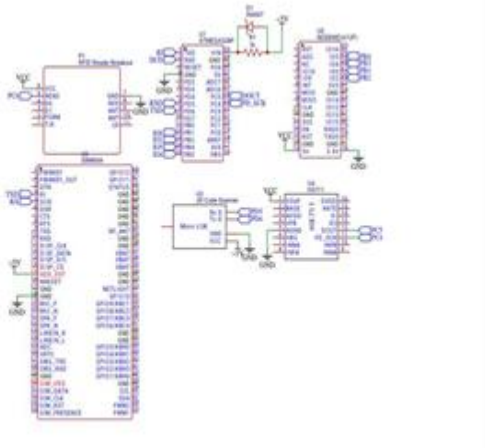

Figure 3: Schematic Diagram

IV. LITERATURE SURVEY

Abdul Salam Mubashar Etal (2020) presents an IoT-based system designed to monitor and control environmental factors affecting grain quality during storage. The system employs sensors to measure temperature and humidity, transmitting data to a cloud platform for real-time analysis. The authors discuss how this approach can reduce post-harvest losses and maintain grain quality [1].

Mir Sajjad et al. [2021] introduces an IoT-based monitoring system that utilizes an Android application to oversee grain storage conditions. The system deploys sensors to collect real-time data on temperature, humidity, and CO_2 levels within storage facilities. The information is then relayed to users via a mobile app, enabling timely interventions to preserve grain quality [2].

E.A Aji segiri et al. (2022) developed and tested an automated intelligent silo bin grain storage environmental control system using IoT. The system monitors and regulates environmental parameters such as temperature and humidity to maintain optimal storage conditions. The authors highlight the system's potential to reduce post-harvest losses and improve grain quality during storage [3].

Fatih BASCIFTCI et al. (2021) measured the humidity and temperature values of cereals in a prototype silo using an IoT-based real-time system. The data collected was transmitted to a central system for monitoring and analysis, allowing for immediate adjustments to maintain optimal storage conditions [4].

S. Priyadarshani (2023) explores the application of IoT technologies in food grain storage systems. It discusses various IoT-based solutions designed to monitor environmental parameters, detect spoilage, and manage inventory in grain storage facilities. The authors provide insights into the benefits and challenges associated with implementing IoT in this sector voting systems [5].

Mr. A. Kathiresan [2020] addresses inefficiencies in India's Public Distribution System (PDS), such as pilferage, long queues, and unauthorized distribution. The proposed system integrates RFID technology for beneficiary authentication, GSM modules for real-time communication, voice recognition for accessibility, and Arduino-based automation for dispensing. By interlinking Aadhaar, Smart Cards, and mobile numbers, the system aims to enhance transparency and reduce human intervention in ration distribution. [6]

Kalawathi D. H. and B. P. Harish [2019] Proposes an automated system that utilizes biometric authentication to identify beneficiaries, ensuring that only eligible individuals receive rations. The system employs load cells for accurate measurement of dispensed grains and integrates real-time data updates to a central server for inventory management. The goal is to eliminate inaccuracies and prevent unauthorized distribution, thereby improving the efficiency of the PDS.[7]

Prof. S. M. Karmuse [2021] introduces an automated dispenser designed for cereals and grains, aiming to replace manual filling and weighing processes in grocery stores. Customers input the desired quantity via a keypad, and the system dispenses the exact amount using motors and sensors. While not directly related to PDS, the system's automation and accuracy principles are applicable to ration dispensing scenarios.[8]

V. RESULTS AND DISCUSSION

The IoT-based grain dispenser system was successfully implemented and tested in a controlled environment to evaluate its performance in terms of accuracy, efficiency, security, and usability. The results indicate that the system achieved its objectives

and demonstrated clear advantages over the traditional manual distribution method.

One of the key outcomes observed during testing was the accuracy of dispensing. The load cell integrated with the HX711 amplifier consistently measured grains with high precision. Across multiple trials, the system maintained an error margin of less than ±2 grams for quantities up to 5 kilograms. This proves the effectiveness of the automatic cutoff mechanism controlled by the microcontroller, which stops the motor once the target weight is achieved. Compared to manual weighing, which is prone to human error and manipulation, the automated measurement ensures fairness and transparency in grain distribution.

5.1 Enclosure and Setup

The system was assembled on a breadboard and tested using regulated DC power supply. All modules were interfaced with the Atmega328P microcontroller as per the circuit diagram. The LCD display was mounted for user interaction, and the QR scanner was positioned for easy access. The load cell was calibrated using standard weights, and the GSM module was configured with a valid SIM card for SMS alerts.

5.2 Select Grain

The user selected the grain type using the keypad. The LCD displayed available grain options (e.g. wheat, Rice). The selected grain was stored in the microcontroller memory for dispatch.

5.3 Scan ID

The user scanned their ID card. The system verified the ID against stored records. If valid, the LCD displayed ‘ID verified’. If invalid, the system displayed ‘Access Denied’.

5.4 Start Dispatch

If both ID and QR code were verified successfully, the system activated the relay module to start grain dispensing.

5.5 Grain Dispatched

Once the selected weight was achieved, the microcontroller deactivated the relay. The LCD displayed 'Dispatch'.

The user authentication and security features of the system also performed effectively. The RFID module and QR code scanner verified the identity of ration beneficiaries within 2–3 seconds, making the process quick and reliable. Unauthorized attempts were denied immediately, preventing the misuse of ration cards or duplicate entries. By linking the system with Aadhaar-based authentication, an additional layer of security was introduced, which ensures that only legitimate beneficiaries can access subsidized grains. This directly addresses one of the major problems in the current Public Distribution System (PDS), where duplicate and fake ration cards are often used to siphon resources.

In terms of communication and data logging, the dual approach using Wi-Fi (ESP8266) and GSM proved to be highly efficient. Real-time transaction details, including user ID, quantity dispensed, and stock balance, were successfully uploaded to the cloud without delay. Simultaneously, SMS notifications were sent to beneficiaries and administrators for each completed transaction. This dual communication mechanism not only improves accountability but also provides redundancy in cases where internet connectivity may be weak, ensuring that no data is lost.

The overall efficiency and usability of the system was another significant improvement over traditional methods. The automation reduced the average transaction time per beneficiary, thereby minimizing queues in ration shops. The LCD display provided clear instructions to users, and the keypad interface allowed easy selection of grain type and quantity. During user trials, feedback indicated that beneficiaries found the system more reliable, convenient, and transparent than the manual method. This demonstrates the potential for the system to significantly improve user satisfaction in real-world deployment.

When compared with earlier works cited in the literature, which primarily focused on grain storage monitoring and quality maintenance, the proposed system provides an end-to-end automation solution for the distribution process. This makes it more relevant for large-scale implementation in India's PDS, where the major challenge lies not only in preserving grain quality but also in ensuring secure and transparent delivery to beneficiaries.

However, the system does have certain limitations. At present, the prototype supports only limited types of grains and a maximum dispensing capacity of 5 kilograms per cycle. Additionally, since cloud connectivity is integral to real-time monitoring, uninterrupted internet access is essential. In rural or remote areas with poor connectivity, this requirement may present challenges. Despite these limitations, the system has shown strong potential as a cost-effective and scalable solution for addressing inefficiencies in the PDS.

Overall, the results confirm that the IoT-based grain dispenser is capable of improving accuracy, preventing misuse, ensuring transparency, and reducing manual effort in ration distribution. The system not only meets the immediate objectives of this research but also demonstrates scalability for future enhancements, such as biometric authentication, mobile app integration, and solar-powered operation, which could further improve its usability and adoption in diverse environments.

VI. CONCLUSION

The IoT-Based Grain Dispenser Machine presents a transformative solution for automated grain management in agricultural, industrial, and warehouse applications. By integrating smart sensors, IoT connectivity, and real-time monitoring, the system enhances efficiency, reduces wastage, and improves storage conditions. The automation reduces human intervention, ensuring accurate grain dispensing and optimizing resource utilization. Furthermore, AI-driven analytics and remote access capabilities make the system more scalable and adaptable for different industries. With proper implementation, this project can contribute significantly to food security, economic savings, and sustainable agricultural practices.

VII. FUTURE SCOPE

- Biometric Authentication:
  - Add fingerprint or iris scan for enhanced security.
- Mobile App Integration:

- Allow users to view balance, receive alerts, and manage accounts.

-Solar Power Support:

- Enable operation in rural or low-power areas.

- Voice and Language Support:

- Assist illiterate users with voice guidance in regional languages.

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