Advanced interdisciplinary techniques for revolutionized government ration dispensing system using IoT

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Abstract. The Indian Government is providing grains to those in need at affordable prices through a process known as the Public Distribution System. However, the current distribution methods employed in the public distribution system rely on manual processes, which may lead to errors, be time-consuming, and foster corruption. To address these issues, the proposed work employs Advanced Interdisciplinary Techniques such as RFID cards and readers to authenticate ration cardholders and ensure precise ration dispensing, significantly reducing inaccuracies and fraudulent activities. Furthermore, it incorporates a GSM-based mechanism with OTP authentication, adding an extra layer of security and efficiency. The GSM module sends a one-time password (OTP) to the user’s registered mobile number before dispensing rations, ensuring that only authorized individuals receive their entitled goods. Customers can select the goods they need from the allocation provided by the Government, and the amount will be automatically deducted from their RFID card based on the goods selected. A microcontroller manages the motor and relay to dispense items, while an alarm system alerts in cases of incorrect OTP entries, effectively deterring unauthorized access to rations. This system promises to make the ration distribution process more efficient, transparent, and accountable.

Incorporating Advanced Interdisciplinary Techniques for Revolutionized Government Ration Dispensing System Using IoT.

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1 Introduction

The Public Distribution System, a key welfare initiative by the Indian Government is to provide essential grains to vulnerable populations at subsidized rates. Throughout history, this initiative has been vital in addressing food security concerns and alleviating hunger among its citizens. The Public Distribution System (PDS) has faced challenges due to its reliance on conventional, manual distribution methods. These methodologies have created vulnerabilities in the system, leading to errors in allocation, longer processing times, and increased susceptibility to corrupt practices. This research presents a new way of thinking about the PDS framework, driven by technology and powered by the ingenuity of the Raspberry Pi Pico. This solution used for enhancing the Public Distribution System (PDS) embodies advanced interdisciplinary approaches at every stage of its development and deployment by integrating cutting-edge RFID authentication, and GSM-based OTP mechanisms, the proposed solution seeks to revolutionize the existing distribution mechanisms. Once the user gets identified through the RFID card, an OTP is sent to the registered mobile number through the GSM module, ensuring an additional layer of verification and security. Furthermore, this technologically enhanced system introduces a seamless transaction process. Upon successful verification, users can select the desired type of grains or commodities. The corresponding value of the selected item is then automatically deducted from the user’s RFID card balance, streamlining the distribution process and minimizing manual interventions. A microcontroller manages the motor and relay to dispense items, while an alarm system alerts in cases of incorrect OTP entries, effectively deterring unauthorized access to rations. The constraint of the amount of goods given to the citizens will be according to the government’s ration distribution policies. The research delves deeply into the development, deployment, and expected outcomes of these interdisciplinary techniques, aiming to enhance the efficiency and integrity of the broader PDS system.

2 Existing Methods

The authors of [1] propose an Automatic Ration Dispensing System. Using the Master Key method and fingerprint authentication process, the MASTER KEY is a user password shared only with a government-authorized person, and the government officer will place the finger on the fingerprint sensor to scan and verify. The customers also need to verify themselves using biometrics to verify and take the commodities. If the master key either fails or malfunctions, it could disrupt the entire distribution process which is a drawback to consider. The authors of [2] propose a smart card Reader interfaced with the ARM that is used to get the materials from the shop by the customers. It mainly focuses on minimizing manual work as there is much corruption going on. All the transactions are recorded and sent to the Government Database through the GSM Module. It involves the Government recording every dispense and also verifying whether the provided goods are of lower quality products than the actual product provided by the government. The authors of [3] present an embedded system paper where the customer gives the input of goods and once the verification is done the system will automatically collect that much amount into the container. Ensuring the continuous operation of the embedded system would necessitate regular maintenance, software updates, and hardware replacements, adding to operational costs.

The authors of [4] address a concern on the Supply of ration which can be solved by using an Aadhar card which consists of a QR code, encoded with an Aadhar number and the details of a user will be added using an android application and information is stored and recorded as it is entered using a database. It will also be responsible for maintaining logs. Implementing a system that processes Aadhar card details, database entries, and SMS notifications requires robust security measures to protect against potential cyber threats, data
breaches, hacking attempts, or unauthorized access. The authors of [5] demonstrate the use of Raspberry Pi, a camera module, and the QR present on the Aadhar card as an alternative to ration card. When the data gets checked, the allocated grains are distributed to the customers, and the main database is created which can be accessed by both citizens and government officials. This paper ensures corruption-free ration but Scanning Aadhaar card QR codes and maintaining a centralized database raises concerns about data privacy, security breaches, unauthorized access, or misuse of sensitive information. The authors of [6] discuss the use of a user-friendly system to prevent malpractice by using Three Level Authentication. The system's goal is to build a fingerprint-matching algorithm for user identification. It uses Node MCU, RFID tag, and Fingerprint Scanner. Achieving seamless interoperability and integration with existing Public Distribution System (PDS) infrastructure, databases, government platforms, or third-party services could pose significant challenges.

The authors of [7] have used RFID technology instead of a Ration Card for identification and once the verification is done, the number of items will be displayed and the consumer needs to choose using the keypad, the materials are provided without external help and the entire purchase information is sent to their mobile number. The authors of [8] explore the manual intervention in weighing the materials and illegal use of remaining goods without prior knowledge of ration card holders. Every family head is given an RFID card which has a unique ID number. Once the customer is validated through the fingerprint scanner, the system activates the process and the customer gets material by weighing on the load cell and confirmation is given by pressing a small push button. The success of the fingerprint verification system relies on its accuracy in identifying individuals. Factors such as worn-out fingerprints, dirt, moisture, or other external factors might affect the system's reliability. The authors of [9] propose an Automated Vending Machine that allows consumers to complete transactions of ration with ease. All the process is automated. Customer identification is done by fingerprint verification. Developing and deploying an Automated Vending Machine system integrated with biometric technology may require a substantial initial investment in hardware, software, infrastructure, and training. The authors of [10] have proposed an automated Ration Material Distribution System based on Bluetooth technology instead of a ration card to get goods provided by the government. The user is identified through fingerprint scanning and the entire process is based on a serial communication app installed in the customer's phone which facilitates communication between the phone and the system.

3 Proposed Method

3.1 Problem Statement

Despite the praiseworthy efforts of the Indian Government to supply affordable grains through the Public Distribution System (PDS), the existing manual distribution methods are riddled with inefficiencies, inaccuracies, and widespread corruption. These persistent issues not only thwart the system's goals but also jeopardize the well-being of countless individuals reliant on these essential provisions. The lack of an efficient, technologically-driven system has impeded the effective distribution of rations, resulting in potential wastage and unauthorized usage. Hence, immediate intervention is necessary to incorporate contemporary technologies like RFID cards and GSM-based OTP authentication to modernize the PDS. This study seeks to rectify the deficiencies of the prevailing system by advocating for a technologically sound approach that ensures accurate ration allocation, reduces errors, fosters transparency, and substantially diminishes fraudulent activities, thereby refining the distribution process to better serve its designated beneficiaries.
3.2 Objectives

- To develop and implement a secure, efficient system for distributing rations to citizens.
- Leveraging IoT technology streamlines the entire ration distribution process, goods selection, amount deduction from RFID cards, and dispensing.
- To create a user-friendly system, ultimately contributing to the improvement of governance in the Public Distribution System and the socio-economic welfare of the citizens relying on subsidized food grains.

3.3 Architecture Diagram

EM-18 scanner senses the Tag inside the RFID card and identifies the user. The GSM module is used for communication purposes with the user in case of Authentication and others. This entire information is passed down to the central hub, Raspberry Pi Pico, which processes the data and controls the execution. LCD shows the needed display to the user and the alarm sounds in case of wrong OTP entries. The L293 D Motor Driver Activates when the input regarding which item to dispense is selected by the user through a keypad as illustrated in Fig. 1.

Fig. 1. Architecture Diagram

3.4 Modules and its Description

Three modules comprise Data Input, Data processing and Authentication, and dispensing.

3.4.1 Module 1: Data Input

The RFID card acts as an Access Control for the beneficiary information just like a card. The EM-18 Reader Module captures the User’s RFID card tag identifies the user and sends the information to the central hub. The Keypad manually takes the input from the user in case of choosing a particular option or entering OTP and this entire information is further sent to the main hub.

3.4.2 Module 2: Data Processing and Authentication

The LCD Displays the ongoing process, informs the user, and interacts with the user in each process. The Raspberry Pi Pico acts as the main brain of the system, receiving input from the
input module, determines each process, and triggers the appropriate measures to be taken. The GSM SIM-800 Module plays a pivotal role in authentication and providing secure communication between users and the model. The Buzzer alerts the user when there is a wrong entry of OTP.

3.4.3 Module 3: Dispensing

The L293 D Motor Driver powers and controls the two motors and activates the required motor according to the input given by the user. The Motor starts running when it gets its power and input from the L293 D Motor Driver and the motor spinning dispenses the goods to the user.

4 Results and Discussions

4.1 Experimental Results

The following is a brief explanation of the Experimental Results of Revolutionized Government Ration Dispensing System using IoT. The success of the proposed ration distribution system relies on a thorough evaluation of all processes. In terms of detection accuracy, the EM-18 RFID scanner ensures accurate detection of RFID cards that work at 125KHz and demonstrates exceptional accuracy in reading RFID cards within a specified range. Its robust performance is evident in various environmental conditions, including different lighting scenarios and diverse temperatures. When users bring their cards close to the EM-18 Module, the microcontroller captures and processes the data, and displays the corresponding card number on the screen. This step sets up a dependable identification mechanism that allows users to interact in subsequent steps with confidence, achieving a higher accuracy rate of RFID card detection.

Upon successful RFID verification, the system fortifies its security measures through the implementation of OTP authentication via the GSM module. The GSM module’s performance in sending one-time passwords was evaluated for speed and reliability. Users receive a unique OTP on their registered mobile numbers, which successfully sends OTPs within an average time of 3 seconds when the signals are high, contributing to the system’s efficiency and security. The input has been accurately entered using a keypad with no errors or inconsistencies. The input has been accurately entered using a keypad with no errors or inconsistencies. Any discrepancy, such as entering an incorrect OTP, triggers an immediate response. A red light coupled with a buzzer serves as an alert mechanism, indicating a potential security breach or malpractice. The alarm system responded promptly to incorrect OTP entries, deterring unauthorized access attempts.

As users progress through the authentication phase, the green light starts glowing, and the user is ready to make good selections. The L293 D microcontroller effectively manages the motor and relay for dispensing items. Dispensing tests with different goods and quantities showcased smooth and precise operations and achieved a response time of less than 2 seconds for dispensing, ensuring timely and accurate ration distribution. Depending on the user’s choice, the corresponding motor springs into action, ensuring precise and timely commodity allocation. The financial aspect is seamlessly managed. The system deducts the appropriate amount from the user’s card balance based on the chosen goods. Concurrently, a message is dispatched via SMS to the registered mobile number, detailing the goods procured, the deducted amount, and the remaining balance.

The LCD interface was clear under various lighting conditions, providing users with essential information about allocated goods and remaining balance. User interaction and
notifications play a crucial role in providing a smooth and seamless user experience. Finally, evaluating overall system performance, including how quickly it responds from all the sensor detection to notification, is essential for understanding the efficiency and reliability of the entire system in fulfilling its authentication and allocation goals. Raspberry Pi Pico manages the entire process and interaction between the components. The following are the steps of the environment:

**Working Setup:** All the components and modules are connected per the architecture diagram in Fig. 2. This figure indicating all the components are working properly with the power supply.

![Proposed Kit](image)

**Fig. 2. Proposed Kit**

Data Input: When the RFID card is scanned through the EM-18 module its user ID is displayed on the screen and the identification of the user is done by the microcontroller.

![The card number Displayed](image)

**Fig. 3. The card number Displayed**

Enter OTP: After successful user identification, the user is asked to enter the OTP which the user will receive on the registered mobile number.

![Enter OTP on the screen](image)

**Fig. 4. Enter OTP on the screen**
Correct OTP: Once the entered OTP is correct, there will be a display on the screen that the entered OTP is correct.

![Correct OTP Display](image)

**Fig. 5. Correct OTP Display**

Item selection and amount deducted: Once the option is entered by the user, the L293 D module passes the command to that respective motor to dispense the goods to the user.

![Item Selected and Amount Deducted](image)

**Fig. 6. About the Item Selected and the amount deducted**

Message received by the user: After the entire process, an SMS is sent to the user’s registered number regarding which item was dispensed, the amount deducted, and the remaining balance.

![Item Dispensed Info via SMS](image)

**Fig. 7. Item Dispensed info sent via SMS**

Wrong OTP: Once the entered OTP is not correct, there will be a display on the screen that the entered OTP is wrong and the buzzer will start to make a sound.
4.2 Significance of the Proposed Method

The proposed system offers a revolutionary solution to the prevalent challenges within the Public Distribution System (PDS) of the Indian Government. Integrating RFID cards and readers provides a reliable and technologically-driven authentication process for ration cardholders. This innovation has significant implications for eliminating existing errors, reducing time-consuming manual processes, and curbing corruption within the distribution framework. Incorporating a GSM-based mechanism with OTP authentication provides an additional layer of security and demonstrates our commitment to safeguarding the distribution process. This proactive measure ensures that only authorized individuals receive their allocated rations, contributing to a higher level of integrity within the entire system. The user-friendly interface allows customers to choose goods from the government's allocation personally. The process is streamlined with automatic money deductions from RFID cards based on the selected item and the card balance. This makes the process efficient and tailored to the specific needs of the beneficiaries, providing significant benefits to them. In essence, the proposed system embodies a transformative approach to the ration distribution process, ensuring efficiency, transparency, and accountability. Its advantages extend beyond technological innovation to address societal challenges, ultimately contributing to the welfare and empowerment of citizens reliant on subsidized food grains.

5 Conclusion and Future Enhancements

The proposed interdisciplinary system that uses RFID and GSM technology marks a significant improvement in the PDS infrastructure. The system offers accurate authentication, and transparent operations, and allows users to choose what they need. This addresses the critical issues of the current system. The research conducted on this system opens doors to a future where efficiency, accountability, and empowerment of beneficiaries define the PDS landscape. This will ensure that the rightful beneficiaries receive their entitlements with transparency and dignity. The interdisciplinary system that has been designed is an excellent example of how RFID technology, microcontroller functions, secure OTP authentication, automated dispensation mechanisms, and integrated financial transactions can work together in harmony. This integration results in improved user experience, security, and financial transparency, and it also highlights the potential for the system to be used in various contexts. By promoting transparency and accountability, the system lays the groundwork for optimal resource allocation and policy decision-making, which ultimately results in a more efficient and equitable PDS experience for all stakeholders involved. This interdisciplinary perspective underscores the importance of considering diverse factors, such as usability and accessibility, in technological solutions aimed at social welfare initiatives like the PDS. This research highlights how interdisciplinary techniques can transform the Public Distribution
System (PDS) by improving authentication, making transactions more secure, and empowering beneficiaries. This could lead to a future where leakages and fraud are eliminated. Additional research and pilot papers can refine and demonstrate the scalability of this solution, paving the way for a PDS that better serves the needs of millions of people in India.

The proposed enhancements for the Revolutionized Government Ration Dispensing System promise a remarkable evolution in its capabilities and responsible practices. Data Analytics and Predictive Modeling: Incorporate advanced data analytics techniques to analyze consumption patterns, identify areas of high demand, and predict future requirements. It helps in optimizing grain allocation and distribution logistics. Mobile Application: Develop a user-friendly mobile application that allows ration cardholders to check their entitlements, view transaction history, and receive notifications. Feedback from all the users or report any issue. Biometric Authentication: Integrate biometric authentication (fingerprint or iris scanning) along with RFID and OTP mechanisms to further enhance security and ensure that rations are distributed to the rightful beneficiaries.

References