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RFID Based Smart Ration Card and Product System

Mahalakshmi. S[1], Sandya. S[2]

[1]Assistant Professor, GradeI Dept of AI&DS, Panimalar Engineering College, Chennai
[2]UG Scholar Dept of AI&DS, Panimalar Engineering College Chennai

Abstract
This paper describes the design and implementation of an RFID-Based Smart Ration Card and Product System to enhance the efficiency, transparency, and security of the Public Distribution System (PDS). The solution replaces conventional paper ration cards with unique RFID cards, streamlining beneficiary authentication through contactless technology. On approaching a distribution center, a user presents their RFID card, which is read by an RFID scanner interfaced to a microcontroller such as STM32 or Arduino. The system retrieves user records from a central database, often leveraging IoT modules like ESP32 for real-time cloud connectivity. For secure transactions, the system integrates OTP authentication or biometric verification alongside RFID identification, ensuring that only verified recipients can access rationed commodities. The automated dispensing process utilizes actuators and sensors for accurate measurement and delivery of allotted goods. All actions, including product dispersal and user verification, are clearly communicated to users via an LCD display and logged for audit trails. Administrators can remotely monitor stocks, transaction histories, and user activity through the system's cloud backend, while beneficiaries receive real-time notifications. This approach significantly reduces human intervention, minimizes pilferage, and combats malpractice in ration distribution. The system can also be tailored for different commodities and integrated with government databases, providing a scalable and adaptable platform for welfare services.

Keywords: RFID (Radio Frequency Identification), Smart Ration Card, Public Distribution System (PDS), Automated Ration, Product Dispensing, IoT (Internet of Things),OTP Authentication, Fraud Prevention, Stock Monitoring, Transparency, Welfare Services, Remote Monitoring, Transaction Logging, User Verification.

I.INTRODUCTION

The Indian Public Distribution System (PDS) is a vast network established to deliver subsidized food and essential commodities to millions of families, especially those living below the poverty line (BPL), as well as other designated beneficiary groups. The ration card serves as a critical identification and entitlement document for accessing these government welfare schemes, ensuring food security for vulnerable populations. However, traditional paper-based approaches in the PDS have long suffered from persistent challenges such as fake card issuance, diversion of goods, corruption, lengthy queues, manual errors, and poor inventory management [1]. Many legitimate beneficiaries are deprived of their rightful provisions due to these inefficiencies and malpractices.

To address these shortcomings, the Smart Ration Card and Product System leverages modern technology

to automate, secure, and streamline the entire ration distribution process. Central to this solution is the adoption of RFID (Radio Frequency Identification) smart cards, microcontrollers, and digital displays. Each beneficiary is issued an RFID smart card embedded with a unique identification number and personalized data regarding entitlements and transaction history. Upon arrival at a ration shop, beneficiaries scan their RFID card at an RFID reader. The card's data is authenticated against a government-maintained database by a central processing unit—typically an ARM-based microcontroller—which serves as the system's control core.

This system utilizes RFID cards embedded with unique beneficiary information, allowing contactless and rapid authentication at ration shops through RFID readers integrated with microcontrollers and IoT modules for real-time data exchange [2].The automated platform records transaction details, monitors inventory, and sends SMS notifications to beneficiaries, enhancing transparency and minimizing corruption. Additionally, biometric verification or OTP authentication is incorporated to ensure authenticity, further reducing fraudulent access. The system empowers beneficiaries by providing accurate, timely information on their entitlements and facilitates efficient product dispensing, thereby improving service delivery.

The transformative potential of this RFID- based smart ration system lies in its ability to streamline the entire distribution chain, minimize malpractices, and enhance operational efficiency [3]. Beneficiaries enjoy faster service, transparent access to information, and timely notifications, while administrators benefit from improved accountability and data-driven decision-making. As a scalable and adaptable solution, this technology aligns perfectly with broader digital governance initiatives and the goal of creating inclusive and corruption-free welfare systems

EXISTING SYSTEM

RFID-based smart ration card systems implemented on a large scale aim to revolutionize the public distribution system by addressing challenges such as corruption, lack of transparency, and inefficiency. In this system, eligible beneficiaries are issued unique RFID cards containing their personal details and ration entitlements, stored both on the card and in a central database. At ration shops, RFID readers scan the cards to authenticate the beneficiary, verify their entitlement, and authorize the dispensing of the allotted quantity of subsidized goods. The process involves several steps: beneficiary registration, card issuance, hardware setup at ration shops (including RFID readers, POS terminals, and network connectivity), verification during purchase, and real-time recording of transactions. Some systems also incorporate biometric verification (fingerprint scanning) alongside RFID for an added layer of security, preventing fraud and ensuring only authorized users receive rationed goods. Automated dispensing mechanisms using servo or DC motors control release of solid and liquid ration items, with load cells and

flow sensors ensuring accurate measurements.

Transaction details are updated instantly in the central database, enabling transparent monitoring, stock management, and report generation. Systems may also send SMS alerts to beneficiaries and authorities, enhancing accountability. Training for operators and educating beneficiaries on using RFID cards ensure smooth adoption. This technological advancement significantly increases efficiency, reduces human intervention, curbs malpractices, and improves user satisfaction in large-scale ration distribution.

Existing Systems Limitations:

1. High initial setup cost for RFID infrastructure such as tags, readers, microcontrollers, and network connectivity.
2. Dependency on network and internet connectivity can cause transaction delays or failures in remote areas.
3. Privacy concerns regarding biometric data usage and personal information protection.
4. Limitations in targeting correct beneficiaries in densely populated or poorly documented regions.
5. Risk of malpractices by dealers, including diversion of supplies or manipulation of transaction records.
6. Overcrowding and long waiting times may still persist at ration shops despite automation

PROPOSED WORK

The proposed RFID-based smart ration card system introduces several advancements to overcome the challenges of the traditional paper- based distribution process. By integrating RFID technology with microcontrollers such as Arduino UNO, the system automates beneficiary authentication and ration allocation, significantly reducing fraud, leakages, and manual errors. The RFID tag embedded in smart ration cards stores unique identification and entitlement details, which are scanned and verified against a centralized database at ration shops in real time.

Enhancing security further, the system often includes biometric verification, typically fingerprint scanning, providing a dual-factor authentication mechanism that ensures only legitimate beneficiaries receive their entitled goods. The system automates the dispensing of ration commodities through servo-controlled containers, ensuring precise delivery based on entitlement data.

After each transaction, SMS confirmations are sent via GSM modules to inform beneficiaries, fostering transparency and accountability.

Overall, the proposed work leverages real-time data processing, enhanced security, and automation to improve efficiency, accuracy, and user satisfaction in public food distribution systems, transforming them into more reliable, transparent, and user-centric platforms.

The Proposed System's Benefits :

1. Instant SMS notifications to beneficiaries after each transaction, improving transparency and enabling beneficiaries to keep records of their purchases.
2. Improved transparency and accountability as all transactions are digitally recorded and can be monitored by authorities to reduce diversion and black marketing.
3. The system supports integration with IoT and cloud technologies for enhanced monitoring, data analytics, and scalability.
4. Automation of ration dispensing using microcontroller-controlled servo motors, which minimizes manual errors and ensures precise delivery of entitled goods.
5. Better inventory and stock management enabled by real-time data updates, preventing shortages or

overstocking.

LITERATURE SURVEY

Recent research has extensively explored the development of **RFID and IoT-based smart ration distribution systems** to modernize the public distribution system (PDS). Shukla et al. [1] proposed an RFID–IoT framework where authenticated users access subsidized goods, and real-time updates are sent to a cloud server to prevent fraud. Similarly, Padmavathi et al. [2] designed an Aadhaar-enabled smart card system that integrates OTP verification and SMS alerts for secure and transparent ration delivery. In another approach, Vasanthan et al. [3] presented an automated vending mechanism using RFID that minimizes human intervention, while N J et al. [4] combined RFID with Android apps for easy monitoring of ration transactions. Suresh et al. [5] advanced this by creating an unmanned RFID-based distribution machine, ensuring 24/7 access.

Vijayaraj et al. [6] explored unification of multiple bank and smart cards with formula-based authentication in big data environments, which can be adapted for ration authentication. Ankita et al. [7] utilized biometrics with IoT to strengthen security in ration distribution, and Pinto et al. [8] automated the process of material allocation with improved efficiency. Raut et al. [9] compared RFID and biometric authentication using IoT to optimize ration access, while Rao et al. [10] integrated biometric and QR-code verification in vending machines for enhanced reliability. Kurkute et al.

[11] reviewed various automatic ration distribution models and highlighted future directions, whereas Sheebha Anni et al. [12] focused on virtual queuing via Android apps to reduce waiting times. Beyond rationing, Liu et al. [13] applied RFID to production management, demonstrating scalability for multi-variety distribution, which provides insights for PDS adaptation. Collectively, these works highlight that combining **RFID, IoT, biometrics, Aadhaar integration, and mobile applications** can make ration distribution more **secure, transparent, and automated**, addressing issues of corruption, diversion, and inefficiency.

METHODOLOGY

The methodology for implementing an RFID-based smart ration card system involves several key steps. First, beneficiaries are registered, and their personal and biometric details are collected to issue unique RFID-enabled ration cards. The system hardware, including RFID readers, microcontrollers like Arduino Mega or STM32, fingerprint sensors, and communication modules such as GSM or WiFi, is installed at ration shops. When a beneficiary arrives, their RFID card is scanned and their fingerprint is verified for multi-factor authentication, ensuring secure and legitimate access. Upon successful verification, the system allows the beneficiary to select the type and quantity of rationed goods, which are then automatically dispensed through a motor- controlled mechanism. Transaction details and stock updates are recorded in a centralized database, and SMS notifications are sent to beneficiaries to confirm the ration dispensed**.**

Registration and Card Issuance:

The first step involves registering beneficiaries by collecting their personal and biometric data. Each beneficiary receives an RFID-enabled smart ration card that stores their identity and entitlement details securely. This information is also saved in a centralized database for real-time verification.

Hardware and Infrastructure Setup:

Ration shops are equipped with RFID readers**,** microcontrollers (e.g., Arduino Mega or STM32),

fingerprint sensors, communication modules (GSM, WiFi), and automated dispensing mechanisms. The infrastructure ensures seamless scanning, authentication, and ration allocation in a connected environment.

Authentication and Verification:

When a beneficiary visits the ration shop, the RFID card is scanned to read stored data, followed by fingerprint scanning for biometric verification. This dual-factor authentication enhances security by ensuring that only legitimate beneficiaries can claim their entitlements.

Automated Ration Dispensing:

Upon successful verification, microcontrollers control servo motors or solenoid valves to dispense the exact quantity of ration items automatically. Load cells or sensors monitor the dispensing process for accuracy, reducing manual errors and pilferage.

Transaction Recording and Notification

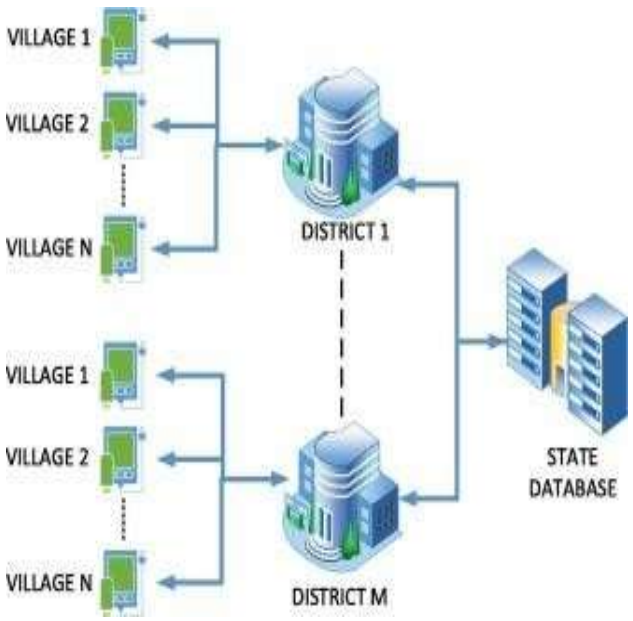
Each transaction is instantly recorded in the central database for transparency and monitoring. Beneficiaries receive SMS or app notifications confirming the details of their ration purchase, empowering them with real-time information.

User Interface and Monitoring

User-friendly LCD displays provide transaction status and prompts during the process. The system supports cloud or local server-based monitoring, enabling authorities to track distribution, identify irregularities, and manage stocks efficiently.

Training and Maintenance

Training programs are conducted for both beneficiaries and ration shop operators to familiarize them with the new system. Regular maintenance of hardware and software ensures robustness, minimizes downtime, and improves system reliability.



ARCHITECTURE

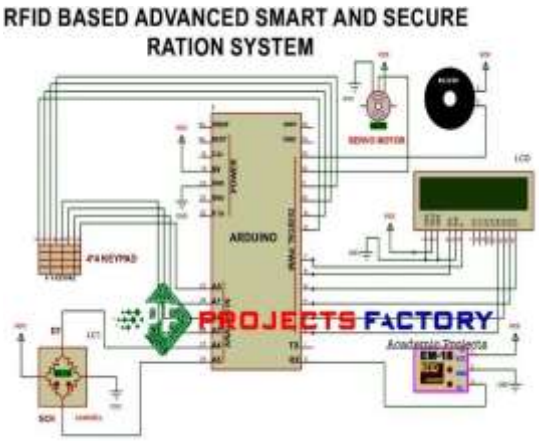
The large-scale implementation of an RFID- based smart ration card system aims to revolutionize the distribution of subsidized food grains by ensuring equitable access, enhancing transparency, and improving efficiency. This system replaces traditional paper ration cards with RFID cards embedded

with unique identification data for each beneficiary. At ration shops equipped with RFID readers and microcontrollers, the cards are scanned to verify the identity of the beneficiary by cross-checking the card information with a centralized database. This verification process often includes additional biometric authentication, such as fingerprint scanning, to prevent fraud and unauthorized access. Once verified, the system automatically authorizes the dispensing of the entitled quantity of ration items, which is controlled by servo motors and monitored using sensors to ensure accurate allocation.

The large-scale system also integrates real-time data synchronization through network connectivity, which helps in updating stock levels and transaction records immediately, allowing for efficient inventory management. SMS or app- based notifications are sent to beneficiaries to confirm transactions and improve transparency. The infrastructure setup includes installation of POS terminals, RFID readers, communication modules, and LCD displays for user interaction.

Additionally, comprehensive training for ration shop operators and beneficiaries is conducted to facilitate smooth adoption.

Implementing this system on a large scale reduces human intervention, curbs corruption, prevents diversion of ration supplies, and shortens queues at ration shops. Continuous monitoring and data analysis allow authorities to detect irregularities and improve service delivery. Overall, the large- scale RFID ration card system provides a technological framework that modernizes the public distribution system, making it more secure, efficient, and user-friendly for millions of beneficiaries.



RESULTS AND ANALYSIS OF PROPOSED WORK

The RFID-based smart ration card and product system represents a significant advancement in the management and distribution of ration supplies, addressing many of the challenges faced by traditional systems. By integrating Radio Frequency Identification (RFID) technology, the system provides each beneficiary with a unique RFID-enabled smart card that securely stores personal identification and ration entitlement data. This smart card is scanned at distribution points, allowing accurate and swift verification of eligibility, which drastically reduces the likelihood of fraud, duplication, and unauthorized access. The automation of the ration distribution process minimizes human involvement, thereby reducing errors and opportunities for corruption that are commonplace in manual operations. Moreover, the system enables real-time data capture and transmission to centralized servers, which facilitates efficient inventory management and transparent monitoring of ration stock levels .

This real-time tracking helps authorities quickly identify discrepancies or shortages, enabling timely interventions to ensure uninterrupted supply to deserving beneficiaries. Integration with biometric verification enhances the security aspect, as biometric data such as fingerprints or iris scans provide an additional layer of authentication, ensuring that only the registered beneficiaries receive the allocated ration. Further, the system can be linked with GSM or IoT technologies to send instant notifications to beneficiaries regarding ration.

Overall, the RFID-based smart ration card and product system demonstrates substantial improvements in transparency, accountability, and efficiency, making it a potent tool for enhancing food security and social welfare distribution. Its successful deployment can lead to significant social and economic benefits by ensuring the timely and just distribution of subsidized rations while curbing corruption and leakage within the supply chain.

CONCLUSION

The conclusion of the RFID-based smart ration card system underscores its transformative impact on public distribution by significantly enhancing transparency, efficiency, and accountability. By replacing traditional paper-based ration cards with RFID-enabled smart cards, the system automates beneficiary identification and ration allocation, drastically reducing human interference, fraud, and corruption. It allows accurate real-time tracking of ration distribution, ensuring that subsidies reach the rightful beneficiaries while preventing misuse and leakages. The integration of RFID technology with centralized databases and biometric authentication further strengthens security and streamlines the rationing process. Additionally, the system reduces paperwork, minimizes administrative overheads, and accelerates service delivery, leading to increased beneficiary satisfaction. Though infrastructure costs and full beneficiary enrollment present challenges, the overall advantages affirm that RFID-based ration systems hold great promise for improving food security and welfare delivery in government programs and humanitarian efforts alike.

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