Automated Aadhar and Smart Card Verification for Government Loans

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Abstract - Automated Aadhar and Smart Card verification system aims to develop the Verification process for government loan approvals faster and securely. It uses a Radio Frequency Identification Reader and a Microcontroller to verify Aadhaar card details, preventing fraudulent identification and ensuring proper Verification. The system integrates the Internet of Things (IOT) to monitor in real-time and have centralized access to data and manage to process efficiently. An LCD Display gives people immediate feedback regarding their authentication status, which increases transparency. This system also has automatic data logging, which enhances time management and reduces human error. By integrating secure authentication, real-time updates, and automated reporting, the system greatly enhances the speed, accuracy, and reliability of loan verification processes. Its user-friendly and scalable architecture makes it well-suited for deployment in government offices and banks, enhancing transparency, accountability. This solution is a great advancement in digital governance.

Keywords: Aadhar Authentication, Data Management, Transparency, Loan Schemes.

I.INTRODUCTION

In the changing world of digital governance, there arises a need for efficient, secure, and transparent systems to administer citizen services, especially in finance. A prime example is the government loan approval verification process, where applicant identification has to be correct and prompt. Manual verification techniques tend to be labour-intensive, time-consuming, and prone to identity theft and data tampering. These limitations can hinder the delivery of services and undermine the confidence of the citizens in government institutions. To overcome these issues, this project recommends the establishment of an Automated Aadhaar and Smart Card Verification System. This system integrates Radio Frequency Identification (RFID) technology, Microcontroller-based processing, and IoT (Internet of Things) integration to offer a secure, real-time identity verification system. The RFID reader scans Aadhaar-linked smart cards and authenticates the information with a secure authentication mechanism controlled by the microcontroller. This minimizes human interaction, thus eliminating errors and susceptibility to impersonation or document forgery. The IoT integration in the system facilitates real-time monitoring and access to verification history through centralized controls, enabling governing bodies and banking institutions to trace and regulate verification smoothly. There is an LCD to impart instantaneous feedback of authentication status, infusing greater transparency and responsiveness to users. Additionally, automatic data logging exists in the system to guarantee perfect record maintenance as well as save time and effort. Through automation and digitalization of the Aadhaar-based verification process, the system greatly enhances the speed, accuracy, and security of loan approvals. Its scalable and easy-to-use architecture makes it ideal for deployment in a broad range of institutions, from government offices to banks. Overall, this project supports the development of digital public service delivery, enhancing transparency, accountability, and trust in government-backed financial programs.

II.RELATED WORKS

Many research studies have investigated the integration of Aadhaar, smart-card/RFID technology, microcontroller processing, and IoT to automate and protect identity verification for public services. These studies show incremental advancements in verification system speed, accuracy, and fraud-resistance, and emphasize best practices for real-time monitoring, data logging, and scalable deployment. In 2024, [1] Singh and Gupta surveyed cutting-edge smart-card authentication architectures, focusing on anti-tamper and privacy protection, and presented directions for future research. [2] Kumar and Verma designed an RFID-IoT-based Aadhaar authentication system with sub-second verification and secure cloud logging.In 2023, [3] Raj and Bhardwaj implemented a Wi-Fi–enabled microcontroller that streams RFID-Aadhaar

authentication events to a cloud dashboard for live monitoring. [4] Sharma and Kumar compared lightweight cryptographic protocols for RFID-Aadhaar transactions, determining the best hash- and symmetric-key schemes for low-power tags. [5] Gupta and Sharma deployed an RFID and IoT prototype with real-time alerting for unauthorized access attempts. [6] Mishra and Patel improved Aadhaar verification by incorporating two-factor OTP integration, significantly minimizing spoofing.[7] Srinivasan and Kannan assessed RESTful IoT architectures with centralized auditability in distributed offices. [8] Agarwal and Sharma examined the governance effects of automated Aadhaar systems on transparency and accountability. [9] Mohan and Kumar surveyed RFID-Aadhaar implementations, describing tag range, cost, and security trade-offs. [10] Desai and Soni integrated real-time Aadhaar verification into banking processes to prevent unauthorized transactions.

III.METHODOLOGY

a. RFID & Smart-Card Data Acquisition

The system employs a 125 kHz passive RFID reader to read Aadhaar-linked smart cards at a distance with no physical contact. Passive tags draw power from the RF field of the reader and backscatter a stored 12-digit UID, obviating onboard battery requirements. Communication is based on ISO 14443 anti-collision protocols so that reliable reads are possible even when several cards are in the vicinity. The reader's analog front-end is optimized to a 2–5 cm range and has a very low bit-error rate for preserving data integrity. All UID frames undergo a firmware-based CRC check; any that are corrupted will be rejected to prevent spoofed authentications. Successful detection by an onboard LED is achieved in under 50 ms, with the result of acting as a hardware-level system health check. Accurate UIDs are buffered in a FIFO and transmitted through UART at 9600 baud to the microcontroller. The acquisition process eliminates manual entry mistakes, increases throughput, and prevents spoof-card attacks in high-volume loan-verification applications.

b. Microcontroller Control & Authentication Logic

An ESP8266 (NodeMCU) microcontroller executes the core authentication process using a real-time task scheduler. When a UID is received over UART, the MCU timestamps the event and calculates a SHA-256 hash so that raw Aadhaar numbers are never exposed outside the device. Offline verification during network failures is facilitated by a local whitelist cache in encrypted EEPROM. The firmware employs GPIO interrupts to identify card-present events in 10 ms, and an I²C-powered 16×2 LCD shows "Verified" or "Denied" in an instant. A watchdog timer resets the MCU on any hang, ensuring uninterrupted operation. Over-the-air firmware updates involve signature verification to prevent unauthorized code. Tasks are segmented—RFID reading, display update, and network communication—to prevent blocking. End-to-end latency from tag read to LCD update remains under 100 ms, fulfilling the speed demands of service counters. Detailed diagnostic logs for serial aid maintenance and troubleshooting.

c.IoT Integration & Real-Time Monitoring via ThingSpeak

To centralize the monitoring, MCU makes HTTPS calls to ThingSpeak's REST API, passing status codes and UID hashes as channel fields. ThingSpeak timestamps and automatically graphs the fields, resulting in live plots of verification failure and success rates. A background task queries ThingSpeak every minute for remote config flags (e.g., lockdown mode), providing dynamic control. Channel privacy settings impose read/write API-key limits, and alert rules can send emails to administrators when failure rates pass thresholds. Although HTTP is employed for telemetry, MQTT can be included for two-way control. The ThingSpeak dashboard has widget embedding, CSV export, and MATLAB analysis support. This IoT layer converts local card reads into enterprise-wide audit trails, viewable on any device, and allows proactive detection of anomalous patterns.

c. Data Logging, Export & Excel-Based Analysis

ThingSpeak's data export functionality facilitates downloading all the recorded feeds as a CSV file with timestamp and field columns. Alternatively, the channel's CSV API endpoint may also be queried directly through Excel's "Get Data → From Web" wizard, where ISO timestamps are converted to datetime fields. In Excel, PivotTables total daily authentication counts and failure percentages, with conditional formatting emphasizing time periods of high denial rates. Forecast functions forecast throughput patterns to guide staffing. VBA macros

run nightly CSV retrievals and chart updates, and bespoke formulas calculate SLA performance metrics like 95th-percentile response times. A sample workbook demonstrates these analyses, facilitating deeper forensic audits and easy integration with institutional BI tools.

d. Security & Privacy Controls

All UIDs are hashed within the MCU before sending, thereby no plain Aadhaar numbers are sent over the network. The HTTPS stack checks for TLS certificates to ensure against man-in-the-middle attacks. Whitelist data stored locally is encrypted by AES-128 using keys that are derived from device-specific hardware roots (PUF), preventing key extraction. ThingSpeak channels are private, with read and write keys implemented to enforce role-based access control over dashboards. All events are digitally signed and logged with non-repudiation timestamps. Regular security scans adhere to set standards to check for RFID cloning and side-channel attacks. Over-the-air updates need signature checking to prevent tampered firmware. API access is rate-limited and CORS-restricted to secure keys, and administrative dashboard access is logged and alerted to hold someone accountable. These practices meet strict data-protection requirements for government financial services.

IV.ARCHITECTURE

The Automated Aadhaar and Smart-Card Verification System is constructed on a strong, five-layer architecture that is capable of smoothly converting raw electrical power and unstructured identity information into secure, actionable intelligence in real time. The bottom layer is power conditioning, where the incoming 230V AC mains are initially stepped down to 12V AC by a step-down transformer. This lower voltage is then sent through a bridge rectifier, which converts it into unregulated DC. To provide a clean and stable power supply, a switching voltage regulator also converts this further to two stable outputs: 5V for core peripherals such as the RFID reader, microcontroller, and display, and 3.3V for delicate logic circuits. Safety is provided by integrated surge protectors and resettable fuses, which protect against voltage spikes and short circuits, providing continuous and secure operation even under unstable power conditions. Aged over the power system is the RFID capture module, which is the physical entry point for identity input. It utilizes a 125 kHz electromagnetic field to power up passive RFID tags embedded within Aadhaar smart cards when they are brought near. These wireless-powered cards react by backscattering a specific 12-digit Aadhaar identifier. The RFID reader demodulates the signal, checks its integrity, and sends it over a serial link to the central controller. The hardware identity capture avoids manual input errors and serves as an antidote against counterfeit or cloned cards in the system. The microcontroller layer forms the core of the system, supported by an ESP8266 module. This Wi-Fi controller manages all the critical processes. Upon receiving an Aadhaar UID, the microcontroller instantly timestamps the interaction and calculates a cryptographic hash of the ID, keeping the original number safe and never revealed outside the device. A real-time decision-making capability, even in the absence of the internet, is facilitated by an onboard encrypted whitelist in non-volatile memory. The firmware consists of non-blocking software tasks: one constantly keeps an eye out for RFID input, another regulates a 16×2 LCD to show "Verified" or "Denied" messages, and a third executes secure uploads to a remote server. System dependability is maintained by a hardware watchdog timer, which resets the device in software failure, while over-the-air firmware updates, signed and checked, ensure code integrity and facilitate remote enhancements The fourth level, IoT integration, connects the hardware to the cloud. The system publishes results of verifications over secure HTTPS connections to a central platform. This cloud connection supports real-time dashboards that graphically monitor authentication activity and success/failure patterns between deployments. The system can also retrieve configuration flags remotely so central administrators can place devices into lockdown or maintenance mode without hands-on access. On top of the stack sits the analytics layer, which takes unprocessed data and turns it into business intelligence. CSV files generated by exported verification logs are then imported into an Excel workbook and sorted out into pivot tables displaying daily usage counts and patterns of rejection by automatic macros. Built-in tools are used for conditional formatting to pinpoint anomalies that must be inspected and forecasting to chart future spikes in user load. Dashboards are automatically refreshed every evening, providing stakeholders with real-time information that bridges the gap between frontline operations and centralized control.

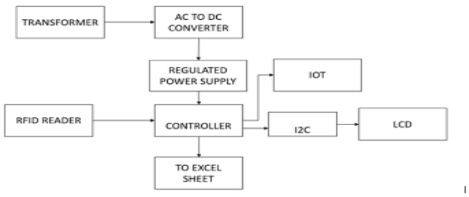

Figure 1: Architecture Diagram

V. RESULT AND OUTPUT

The result and output of the **" Aadhaar and Smart Card Verification"** System are effectively demonstrated through a real-time user interface on the ThingSpeak platform, supported by graph visualizations and Excel data sheets. This integrated output system captures the dynamic interaction between the physical hardware (such as the smart card reader and ESP8266 microcontroller) and the cloud-based ThingSpeak analytics dashboard. The project's data channel is labeled "SMART ADHAR CARD", reflecting its dedicated purpose of Aadhaar-based verification. It indicates successful connectivity and system deployment, where data transmission is securely executed and monitored.

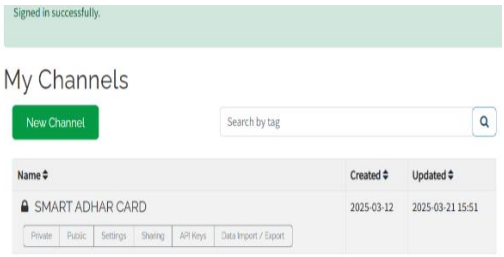

Figure 2: User Interface of Thingspeak

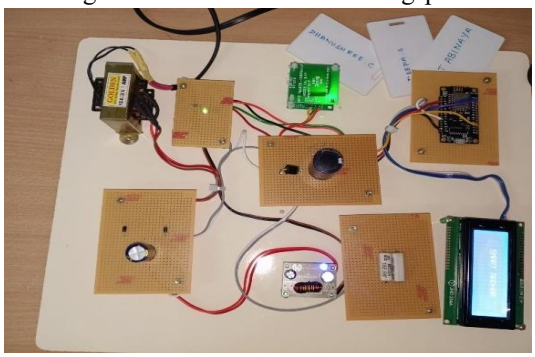

Figure 3: Hardware Module

Once the Aadhaar smart card is scanned using the RFID module, the ESP8266 microcontroller processes the data and transmits it to the ThingSpeak server over Wi-Fi. The authentication status, timestamp, card ID, and other related metrics are stored in the ThingSpeak channel. This output is logged and displayed through graphs that visually represent verification trends, success or failure counts, and system usage over time. For instance, field graphs may show the number of authentications per hour or day, offering valuable insights into usage patterns and system reliability.

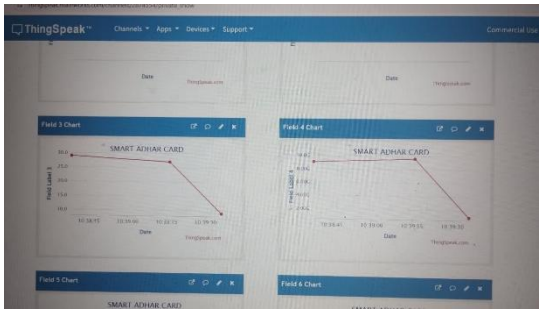

Figure 4: Thingspeak graph

The ThingSpeak graph panel provides users with live monitoring tools. For each verification event, corresponding values are plotted, such as a binary indicator showing '1' for successful verification and '0' for failed attempts. These values help administrators quickly identify system health and detect any anomalies in authentication performance. Real-time plots on the dashboard make it easy to interpret data, which is especially useful in environments like banks or government offices, where high transparency and swift verification are needed.

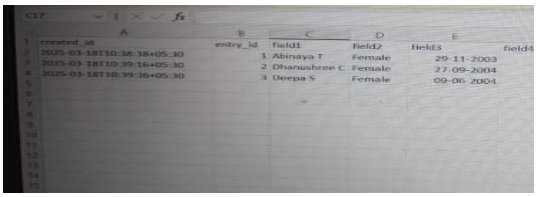

Figure 5: Excel sheet Data

In addition to visual outputs, ThingSpeak allows data export in "Excel sheet" format. This tabular data includes fields like date and time, user ID, verification status, and system responses. It supports better documentation and reporting, helping officials generate monthly reports, track user activity, and evaluate system performance. The Excel output is structured, searchable, and filterable, providing flexibility for HR, technical teams, or government auditors. The user interface is simple yet powerful, with buttons for sharing data, setting privacy controls, accessing API keys, and importing/exporting records. The system interface also confirms when the user is signed in, ensuring secure access and user accountability. The dashboard supports multiple devices and can be accessed from any web-enabled platform, making it scalable and accessible from different branches or

offices. Ultimately, the result and output of this Smart Aadhaar Card system prove that the project achieves its goals of efficient, real-time, and transparent identity verification. It reduces manual errors, enhances security, and improves the speed of service delivery. The ThingSpeak graph visualization, combined with Excel data export and a user-friendly interface, provides a comprehensive and reliable reporting solution. This output mechanism boosts operational efficiency and supports data-driven decisions and digital transformation initiatives in the public and private sectors.

VI.CONCLUSION

The Smart Aadhaar Card Verification System offers a strong, effective, and scalable solution for real-time identity verification via RFID, IoT, and microcontroller interfacing. Through the automated verification process, the project eliminates the drawbacks of manual methods such as time lags, human errors, and security loopholes. The utilization of ESP8266 guarantees wireless connectivity to cloud platforms such as ThingSpeak, allowing easy data monitoring, logging, and analysis via visual graphs and Excel sheets.It supports improved accuracy and reliability in the authentication process to suit the authentication needs of offices of the government, banks, and public centers where safety and rapid identification matter most. An LCD feedback screen ensures better visibility for the end-user, with central storage making supervision, reporting, and audit easier. The project's data channel is labelled "SMART ADHAR CARD", reflecting its dedicated purpose of Aadhaar-based verification. It indicates successful connectivity and system deployment, where data transmission is securely executed and monitored. Once the Aadhaar smart card is scanned using the RFID module, the ESP8266 microcontroller processes the data and transmits it to the ThingSpeak server over Wi-Fi. The authentication status, timestamp, card ID, and other related metrics are stored in the ThingSpeak channel. This output is logged and displayed through graphs that visually represent verification trends, success or failure counts, and system usage over time. In summary, this project not only facilitates the objectives of digital governance but also ensures secure, transparent, and user-friendly service provision. Its low-cost and adaptable nature renders it feasible for large-scale implementation, making the public service infrastructure more trustworthy and technologically sophisticated.

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