

NFC-Based Wireless Railway Ticketing System Using Web Technology

Prof. Santhosh Kumar N

Dept. of Electronics and Communication Engineering
Sri Sairam College of Engineering, Benagluru, India
santoshkumar.ece@sairamce.edu.in

Babitha, Chethan Kumar B N, Deepa S, Madev Naik V

Dept. of Electronics and Communication Engineering
Sri Sairam College of Engineering, Benagluru, India
sce22ec140@sairamtap.edu.com, sce22ec108@sairamtap.edu.com
sce22ec102@sairamtap.edu.com, sce22ec133@sairamtap.edu.com



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Abstract: The conventional paper-based ticketing system for unreserved travel in Indian Railways is plagued by inefficiencies including significant paper waste, susceptibility to fraud, and prolonged passenger queues. This paper proposes a novel, sustainable solution: a reusable ticketing system leveraging Near Field Communication (NFC) technology, accessible entirely through a web interface. The system utilizes durable NFC cards that can be electronically reset and reused for thousands of journeys, drastically reducing operational costs and environmental impact. A cloud-based backend with offline synchronization ensures reliability in low-connectivity areas, while AES-256 encryption and JWT authentication guarantee security. Accessible via a standard web browser on NFC-enabled devices, this system eliminates the need for dedicated mobile applications, offering a scalable, cost-effective, and secure alternative that enhances both operational efficiency and the passenger experience.

Keywords: NFC, Railway Ticketing, Web Application, Reusable Tickets, Cloud Computing, Offline-First

I. INTRODUCTION

The Indian Railways network, one of the largest in the world, facilitates billions of passenger journeys each year. A substantial portion of this traffic relies on the unreserved travel segment, which remains predominantly dependent on physical paper tickets. This legacy system presents several critical challenges. It is environmentally unsustainable, generating over 800 million paper tickets annually [1]. It is financially vulnerable, with an estimated 4-6% of revenue lost to ticket fraud [2]. Operationally, it is inefficient, as manual ticketing and verification processes can take 8-12 minutes per transaction, leading to extensive queues and passenger dissatisfaction, especially during peak periods [3]. While digital solutions like the UTS application have been introduced, they often face adoption barriers. These include dependency on stable internet connectivity, which is unreliable in many parts of India, and the requirement for smartphone app installation and usage, which can be a hurdle for a diverse user base. This creates a clear need for a digital ticketing solution that is robust, universally accessible, and environmentally sustainable. This paper addresses this gap by introducing the design of a reusable, NFC-based ticketing system that operates through a standard web browser. The core contributions of this work are threefold:

1. The design of a reusable NFC ticket lifecycle that transforms the cost structure and environmental footprint of ticketing.
2. The development of a web-native, offline-capable architecture that ensures broad accessibility without the need for app installations.
3. The integration of a robust security framework using industrial-grade encryption and authentication to prevent fraud.

II. LITERATURE SURVEY

Recent research has extensively explored NFC technology for transit systems. Wagner et al. [4] demonstrated the viability of low-cost NFC tags, emphasizing scalability for large-scale deployments. Kim & Zhang [5] focused on secure one-time-use tickets with dynamic encryption, a security model that informs our approach.

The work of Shaikh et al. [6] on Web NFC API confirms its suitability for developing lightweight, browser-based solutions ideal for low-bandwidth environments. For the backend, the cloud security frameworks surveyed by Ometov et al. [7] provide critical insights into securing data transmission and storage. Furthermore, the AES-256 enhancement techniques discussed by Asaduzzaman et al. [8] ensure the cryptographic robustness of the data stored on our reusable NFC tags. Our proposed system synthesizes these concepts into a cohesive architecture specifically tailored to overcome the operational and infrastructural challenges unique to the Indian Railways network.

III. PROPOSED SYSTEM ARCHITECTURE

The proposed system is architected to be robust, scalable, and accessible. Its high-level design, which illustrates the interaction between all key components, is shown in Fig. 1.

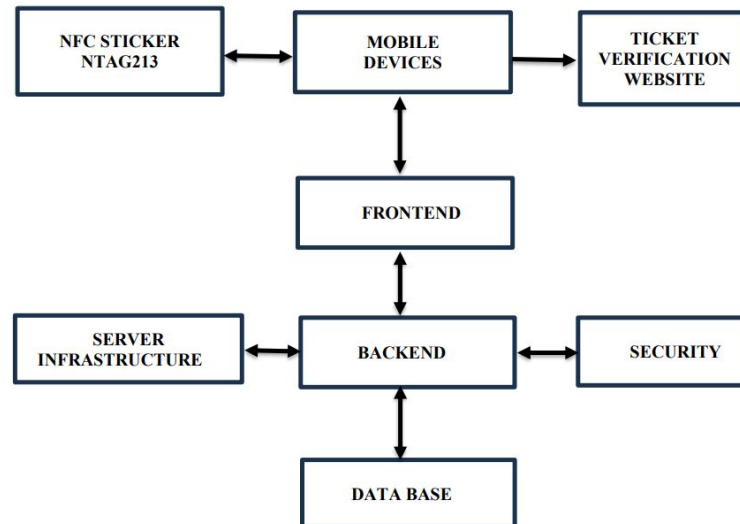


Fig.1 System Architecture Diagram

High-level system architecture showing data flow between NFC Tags, Web PWA, Cloud Backend, and Database

The architecture is built upon three primary layers. The **Presentation Layer** is a responsive React-based Progressive Web App (PWA). This interface is used by both station staff for ticket issuance and by ticket checkers for verification. It leverages the Web NFC API to communicate with the physical tickets and is designed to function seamlessly on mobile devices and in low-connectivity scenarios.

The **Application Layer**, hosted on cloud platforms like AWS India or RailTel Cloud, is built with Node.js and Express.js. This layer contains the core business logic for ticket management, user authentication, and data synchronization. It exposes a set of RESTful APIs that the frontend consumes.

The **Data Layer** relies on Firebase Firestore, a NoSQL database. This choice is pivotal for its real-time update capabilities and, most importantly, its native support for offline synchronization. This ensures that ticket issuance and verification can continue uninterrupted even in network black spots, with data syncing automatically once connectivity is restored.

IV. SYSTEM IMPLEMENTATION

A. Reusable Ticket Lifecycle

A fundamental innovation of our system is the reusable NFC ticket. We employ durable NTAG213 cards, rated for over 100,000 write cycles. The ticket management follows a strict four-state lifecycle:

1. Available: The card is blank and ready for issuance.
2. Active: Journey data is encrypted and written to the card; the ticket is active for travel.
3. Used: The ticket has been scanned and validated; the journey is complete.
4. Reset: The encrypted data is securely erased, and the card is returned to the "Available" pool.

This cycle, managed entirely through the web interface, ensures the physical hardware is utilized thousands of times, making the per-journey cost negligible.

B. Operational Workflow

The sequence of operations between passengers, staff, and the system is depicted in Fig. 2.

Sequence diagram illustrating the ticket purchase and verification process.

The workflow begins when a passenger requests a ticket. The station clerk accesses the web application, enters the journey details, and taps an available NFC card. The system generates a unique ticket ID, encrypts the data using AES-256, and writes it to the card. Simultaneously, a corresponding record is created in the cloud database.

During travel, the ticket checker uses their own device to access the web app and scan the passenger's NFC card. The system validates the ticket's authenticity and marks it as used. Upon completion of the journey, authorized personnel can reset the card, making it available for the next passenger.

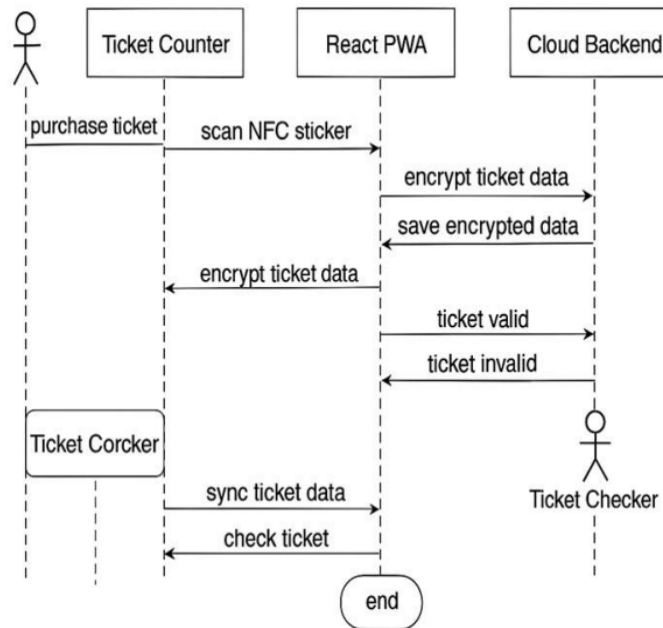


Fig. 2 - Sequence Diagram

C. Security Framework

Security is integrated at multiple levels. All sensitive data on the NFC tags is secured with AES-256 encryption. Access to the web application for staff and checkers is controlled via JWT-based authentication, ensuring that only authorized personnel can issue or verify tickets. Furthermore, each NFC tag has a unique, unclonable factory identifier (UID), providing an additional hardware-level safeguard against duplication.

V. RESULTS AND DISCUSSION

The proposed system is designed to yield significant improvements over existing solutions. A comparative analysis of key performance indicators is presented in TABLE I.

Performance Indicator	Paper System	Single-Use NFC	Proposed System
HighMediumCost per Ticket	Low	Medium	Very Low (long-term)
Environmental Impact	High	Medium	Very Low
Access Method	Physical	Mobile App	Web Browser
Offline Support	Full	Limited	Full
Fraud Resistance	Low	High	Very High

Table I - Comparison Table

Comparative analysis of ticketing systems.

The analysis demonstrates the transformative potential of our system. The reusable model offers superior economic benefits over time compared to both paper and single-use digital tickets. Environmentally, it virtually eliminates the waste associated with its counterparts. The web-based approach provides unparalleled accessibility and ease of deployment, while the offline-first design ensures reliability across India's diverse connectivity landscape. The incorporation of strong encryption and unique hardware IDs provides a level of security that is unattainable with paper tickets and more robust than many first-generation digital solutions.

VI. CONCLUSION

This paper has presented the design of a reusable, web-enabled NFC ticketing system tailored for the Indian Railways. The solution effectively addresses the critical trilemma of cost, sustainability, and accessibility that plagues current ticketing methods. By leveraging reusable hardware, a web-native interface, and a robust cloud-backend with offline capabilities, the system provides a practical blueprint for modernizing public transport ticketing. Future work will focus on the development of a functional prototype to validate the system's performance under real-world conditions. Subsequent enhancements will explore the integration of UPI for seamless payments, the addition of QR codes as a backup verification method, and potential synergy with digital identity systems for streamlined passenger management. This research paves the way for a more efficient, secure, and sustainable future for railway ticketing in India and beyond.

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