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Smart Ticketing System

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Abstract: ***Public transportation infrastructure is currently encountering challenges regarding the efficiency of fare collection mechanisms, passenger congestion, transparency, and making decisions based on data. The following paper introduces a Smart Ticketing System that utilizes digital, contactless, and cashless technologies for improving fare collection mechanisms. The proposed system utilizes Radio Frequency Identification (RFID), Near Field Communication (NFC), QR code scanning, smart cards, mobile wallets, GSM/Wi-Fi communication modules, and cloud infrastructure for enabling seamless and automated ticket validation. The proposed system allows passengers to tap their smart cards, scan QR codes, or use mobile applications for fare collection. The fare is automatically calculated depending on the journey parameters. The proposed system has several advantages, including faster boarding times, minimized human error, and no fare evasion. The proposed system allows for an interactive web application with features such as mapping, dynamic navigation, and recalculation of routes in case of any disruptions. The proposed system ensures access control, encryption, and communication protocols that are used for maintaining privacy and complying with cybersecurity standards. The proposed system is scalable and can be integrated with multimodal transport infrastructure without making any major changes.***

Keywords: Smart Ticketing System, RFID, NFC, QR Code, Cloud Computing, IoT, Cashless Payment, Public Transportation, Real-Time Analytics, Role- Based Access Control, Data Encryption, Multimodal Integration.

I. INTRODUCTION

Public transport is of immense importance for urban mobility, economic growth, and environmental sustainability. Yet traditional ticketing mechanisms are still facing numerous operational challenges, which include queues, manual handling of fare collection, loss of revenue, ticket forgery, and inefficient data management. Paper ticketing and manual transactions not only result in increased passenger boardings but also limit the ability of transport authorities to effectively monitor passenger movement and service delivery. Thus, with increasing urban population, the need for efficient ticketingmechanisms has gained prominence.

With the rapid development of digital technologies like Internet of Things (IoT), cloud computing, wireless communication, and contactless payment technologies, it is now possible to introduce smart ticketing mechanisms that can address existing challenges of traditional ticketing mechanisms. Smart ticketing mechanisms use advanced technologies like Radio Frequency Identification (RFID), Near Field Communication (NFC), QR code scanning, smart cards, and mobile wallet integration to automate ticket validation processes. Such technologies do away with the use of paper tickets and manual verification processes.

Such conventional ticketing infrastructures normally operate in isolation with limited analytical capabilities. This makes it difficult for transport authorities to derive real-time insights related to passenger density, route usage, revenue, etc. In this context, a cloud-based smart ticketing system would be able to store data centrally and monitor it in real- time, thus facilitating data-driven decision-making processes for efficient resource allocation. Additionally, communication protocols, encryption techniques, and access controls would also ensure data privacy.

This paper aims to present a proposal for a Smart Ticketing System that would be able to effectively manage fare collection processes, ensure a better passenger experience, and also provide intelligence for public transportation systems. In this context, it is proposed that a smart ticketing system would be able to integrate contactless technologies, real-time communication modules, and cloud infrastructure to provide automated fare calculation, digital payment processing, etc. The user-friendly interface of the website includes features of an interactive web interface and updates in real time. The architecture of the website is scalable and supports multimodal transportation integration. The main goal of the website is to prevent boarding delays, human errors, fare evasion, and efficient transportation management.

II. LITERATURE SURVEY

This present literature review article offers an in-depth analysis of the research studies pertaining to the modern bus ticketing systems employing technologies such as QR codes, NFC, RFID, cloud computing, and IoT. These studies focus on improving fare collection efficiency, reducing fraud, and enhancing commuter experience through digital solutions.

In the study by Ramesh [1] suggested a QR code-based mobile bus ticketing system in which the user can book their bus tickets through a smartphone app and then a QR code will be created for validation. The QR code will be validated by the conductor while boarding the bus. This system has low deployment costs and faster boarding times. However, this system requires a smartphone for each user.

Singh and Mehra [2] proposed an NFC- based model for ticketing and passenger validation, which allows for contactless fare transactions. In this system, passengers can use their devices with NFC technology to tap and automatically deduct fares. The system can store information regarding each trip in a central database. The use of NFC technology allows for faster transaction speeds, making it more convenient for users. However, its application is limited due to its dependency on devices with NFC technology and high infrastructure costs.

RFID technology has also been widely explored for automated fare management. Thakur et al. [3] presented an RFID-enabled ticketing system where passengers carry RFID cards detected by readers installed on buses. The system automates fare collection and reduces human intervention, improving data accuracy and operational efficiency. However, challenges such as tag collision, data security risks, and issues related to lost or damaged cards remain critical barriers to widespread implementation. Similar concerns were highlighted by Khan et al. [9], who emphasized that encryption and authentication mechanisms are essential to mitigate RFID-based security vulnerabilities in transit applications.

Cloud-based ticketing systems make it easier to scale and make data more accessible. A real-time bus ticketing management system was proposed by Sharma and Gupta [4], which is integrated with cloud computing for efficient ticket booking, route management, and tracking of revenues. Cloud computing makes it possible to synchronize data and access it remotely for efficient management by operators and commuters. Although it has its advantages, there are still issues of data privacy, latency, and reliability of internet connectivity. Li and Zhao [10] reinforced these issues by proposing that scalability can be improved by using a distributed data storage system in a hybrid cloud environment.

The use of Android-based ticket reservation systems can offer improved user experience and ease of access for the users. Bansal et al. [5] developed a mobile application for the reservation of seats in the buses, where the user can check the schedules of the buses and make digital payments through the application. The e-tickets will be sent to the mail ids of the customers, reducing the need for documentation. Even though the application is convenient for the customers, it is not useful for those who do not have the facility to access the application. A similar study by Patel et al. indicated that the use of multiple ticketing options can help bridge the gap between the two groups of people by providing options for both traditional and electronic transaction methods.

IoT-based transportation systems play an important role in intelligent fare management and monitoring. Raj and Srinivasan in their paper [6] discussed IoT-based solutions for transportation systems. They suggested that IoT-based solutions could be implemented using sensors and GPS devices that track buses and update the backend servers. This increases the reliability of the services and improves the safety of commuters. There are some issues related to the cost of implementation and maintenance of IoT-based transportation systems. Gupta and Verma suggested IoT-based modular solutions for transportation systems to avoid hardware costs and ensure efficiency.

In a comprehensive survey carried out on the effectiveness of e-ticketing systems by Dhivya and Priya [7], the authors highlighted the fact that the use of electronic payment systems and tracking systems increases the satisfaction of customers. The authors recommended the use of a hybrid model that combines QR code technology, NFC technology, and cloud storage to ensure cost-effectiveness. This recommendation was in line with the study carried out by Ahmed et al. The authors of this paper demonstrated the effectiveness of a hybrid model in comparison to a single technology model.

Biometric ticketing has also been proposed to improve the level of security and provide personalization services to the passengers. Pal and Yadav [8] in their paper, "Secure Ticketing System Using Fingerprint-Based Validation," proposed the use of a fingerprint-based ticketing system in which the identity of the passenger is verified before boarding the bus. Although the use of such a system improves the level of security and prevents ticketing evasion, it also has its limitations in terms of privacy issues and the cost of hardware required for the system. Singh et al. proposed the use of such a system in the context of premium services where security is of paramount importance.

Mobile ticketing systems for public transport have been extensively explored to ensure efficient fare collection, user convenience, and transparency in public transport systems. In a study done by Kumar [9], a mobile ticketing system for bus transport was proposed, which uses QR codes for verification purposes after a user books a bus seat through a mobile application and generates a QR code for verification by the bus conductor. This reduces paper usage and boarding time for users.

Another intelligent system for bus ticketing was proposed by Li et al. [10]. This system uses a QR code along with a GPS-based verification system.

In this system, a dynamic QR code is used that will only be valid when the passenger is near the pickup point, which is identified using the GPS system. This system will help in preventing ticket reuse and will only allow actual commuters to board the buses. However, the accuracy of the GPS system and the availability of internet connectivity may not be consistent.

Zhao and Huang [11] proposed a blockchain-based ticketing system for public transportation. This blockchain-based ticketing system maintains a record of transactions related to the issue and validation of tickets. This provides immutability, transparency, and auditability of the issued and validated tickets. This prevents any kind of tempering and fraud. The authors have highlighted the added security of this blockchain- based solution over a centralized database. The drawbacks of this solution are the high latency of the consensus process and the storage overhead.

In summary, the literature review points out the fact that digital ticketing technologies are effective in terms of efficiency and user experience. QR codes and NFC technologies are effective in terms of speed, while RFID and cloud-based technologies are effective in terms of efficiency. However, the challenges still persist in terms of device dependency, security, and costs. Future research should focus on the development of hybrid technologies in order to ensure scalability and usability.

III. PROPOSED METHODOLOGY

The proposed methodology (Fig.1) focuses on developing an intelligent and efficient mobile bus ticketing system that utilizes QR code technology, cloud-based data management, and secure payment integration to streamline fare collection and enhance commuter experience. Initially, the system collects user-specific information such as passenger identification details, travel preferences, and ticket booking information through a mobile application. Upon successful booking, a dynamically generated QR code is issued to the user, which serves as a digital ticket for validation during boarding. The QR code contains encrypted ticket data that can be scanned by conductors or onboard scanning devices for real-time verification, ensuring authenticity and preventing fraudulent ticket usage.

The collected transaction and travel data are securely stored in a cloud database, enabling centralized management, real-time availability checks, and analytics for operational decision- making. Preprocessing steps such as data encryption, validation, and format standardization are applied to ensure data integrity and security. The system employs secure payment gateways to facilitate digital transactions, supporting multiple payment methods for user convenience. Additionally, the web-based or mobile application interface provides a user-friendly platform for ticket booking, route selection, and trip management. Through this approach, the system enhances operational efficiency, reduces manual intervention, and minimizes paper usage while providing passengers with a fast, scalable, and reliable ticketing solution. In conclusion, the proposed methodology delivers a modern, technology-driven framework for bus fare management that improves both commuter accessibility and transportation system efficiency.

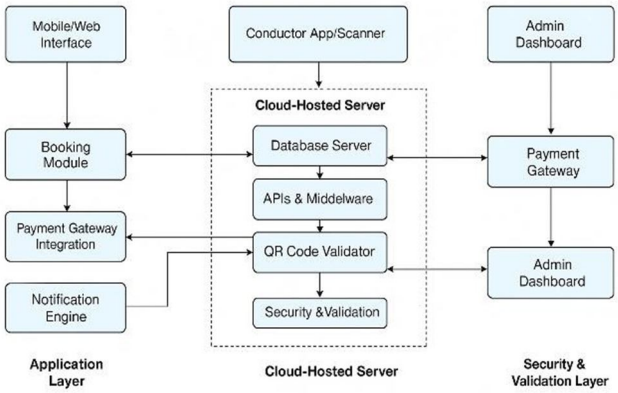

Fig.1. Block Diagram of Smart Ticketing System

A. Hardware Modules

1) QR (Quick Response)

The QR module is a core component of the smart ticketing system used for digital ticket generation and validation. It enables passengers to generate a scannable code after booking tickets through the mobile application. The QR code stores encrypted ticket information such as journey details and payment status. During boarding, the QR code is scanned using a camera or scanner, and the system validates the ticket in real time. This hardware- independent approach enhances accessibility and reduces infrastructure costs while supporting secure and paperless ticketing operations.

Fig.2.Quick Response

2) GPS (Global Positioning Systems)

The GPS module is utilized for real-time location tracking and route-based functionalities in the ticketing system. It captures the geographic coordinates of buses or transport vehicles and synchronizes them with the backend server. This data enables features such as live vehicle tracking, estimated arrival times, and distance-based fare calculation. GPS hardware enhances operational transparency and passenger convenience by providing accurate location information and route optimization capabilities. It also supports analytics for fleet management and service improvement in public transportation systems.

Fig.3. GPS Module

B. Software System

1) UI (User Interface)

User Interface, or UI, is the component of a system that enables interaction between users and the application. It includes visual elements such as buttons, menus, icons, text fields, and layouts that allow users to input data and receive feedback. The primary objective of UI is to provide an intuitive and user-friendly experience so that users can accomplish their tasks efficiently with minimal effort. Tools such as Figma and Adobe XD are commonly used for designing interfaces, while frontend technologies like HTML, CSS, and JavaScript are employed to implement them in web applications.

2) DBMS (Database Management System)

A Database Management System (DBMS) is software used to store, manage, and retrieve data in a structured and efficient manner. It acts as an interface between users and the database, allowing operations such as data insertion, modification, querying, and deletion. The primary purpose of a DBMS is to ensure data consistency, security, and efficient access. DBMS systems prevent data redundancy and provide mechanisms for data integrity and backup.

3) Complete Design Flow

The entire process flow diagram for the proposed smart ticketing system is as follows (Fig. X):

Start the Smart Ticketing System. All hardware and software components, including the Arduino controller, RFID reader module, buzzer, display unit, and serial communication interface, are initialized and prepared for operation.

The passenger approaches the entry point and scans the RFID card on the reader. The system captures the unique UID of the card and temporarily stores it in memory for further processing.

The system performs card validation by checking whether the scanned UID matches the list of registered or authorized cards stored in the program memory or database.

In the decision-making process, the system evaluates the scanned card. This stage contains two different cases:
If the scanned card is valid and recognized, the system proceeds to determine whether the scan corresponds to a boarding event or an arrival event based on the previous scan history.
Invalid or unregistered card – Such cases are immediately detected, and the system triggers a buzzer/LED alert while displaying an "Invalid Card" message to the user.
For a valid first scan (boarding), the system records the boarding location and timestamp associated with the passenger's card ID. A confirmation message such as "Boarding Recorded" or the station name is displayed on the LCD/serial monitor.
When the same passenger scans the card again at the destination, the system identifies it as an arrival scan and retrieves the previously stored boarding data.
The fare calculation module computes the travel cost based on predefined logic such as distance between stations or time traveled. The calculated fare amount is displayed to the user in real time.
User feedback mechanisms are activated, including buzzer beep and visual confirmation on the display, indicating successful processing of the journey.
The system outputs the travel details, including boarding point, arrival point, fare amount, and timestamp, to the serial monitor or connected interface for monitoring purposes.
If required, the calculated fare can be deducted from a stored balance linked to the RFID card or logged for manual payment processing.
All transaction details, including card UID, travel route, fare, and time, are stored in the system memory or external database for future reference and analytics.
The system then resets the temporary variables and returns to the standby state, displaying "Scan your card," ready to process the next passenger.
An optional user interface dashboard can present booking history, upcoming trips, and transaction summaries to administrators or users in real time.
Finally, the system offers the capability to export or download travel and transaction reports for record keeping, auditing, or integration with larger smart transportation platforms.

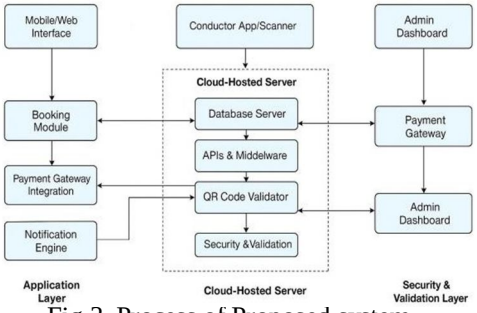

Fig.3. Process of Proposed system

IV. RESULTS AND DISCUSSION

The proposed smart ticketing system demonstrates an efficient and reliable solution in terms of cost, automation, and operational performance for modern public transportation. The system effectively utilizes RFID technology and microcontroller-based processing to automate passenger identification, boarding validation, and fare calculation. The inclusion of real-time processing and validation mechanisms enhances the overall efficiency and accuracy of the ticketing workflow.
The experimental implementation clearly indicates that the RFID-based automated approach performs better than traditional manual ticketing methods in terms of speed, accuracy, and user convenience. The contactless scanning mechanism significantly reduces passenger waiting time and minimizes human errors in fare collection. The use of predefined card validation ensures that only authorized users can access the transport service, thereby improving system security and reliability.
The fare computation module works effectively by calculating the payment amount based on the passenger's boarding and arrival points or travel duration. The system successfully records travel timestamps and computes the correct fare, as observed in the serial monitor outputs. User feedback mechanisms such as the buzzer alert and display messages further enhance usability by providing immediate confirmation of successful scans and transactions.

The integration of a simple monitoring interface allows operators to track travel data, including card UID, travel route, fare amount, and timestamps. The system is also capable of storing transaction logs for future analysis, which can help in understanding passenger flow patterns and optimizing transport operations.

The user interface components, including the LCD prompts and optional web dashboard, make the system easy to operate for both passengers and administrators. Invalid card detection and alert generation improve robustness by preventing unauthorized access. Overall, the results validate that the proposed system effectively combines automation, accuracy, and usability, making it suitable for real-world smart transportation applications.

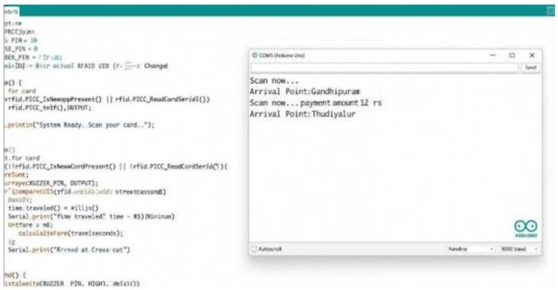

Fig.1. The Output of Proposed System

V. CONCLUSION

The proposed smart ticketing system demonstrates the effectiveness of integrating RFID technology with embedded systems for automated fare collection and passenger tracking. By accurately identifying passengers through RFID cards and computing fares based on travel data, the system provides a fast, reliable, and contactless alternative to conventional ticketing methods. The implementation using Arduino ensures low cost and ease of deployment, making the solution practical for buses, metro systems, and institutional transport. The system improves operational efficiency by reducing manual intervention, minimizing errors, and shortening boarding time. Real-time feedback through the buzzer and display enhances user experience, while transaction logging supports future analytics and system monitoring. The modular design also allows further enhancements such as cloud connectivity, mobile NFC integration, and centralized database management.

Overall, the developed system supports smarter and more efficient public transport management. With further scalability and integration, it has strong potential to contribute to intelligent transportation systems and smart city initiatives.

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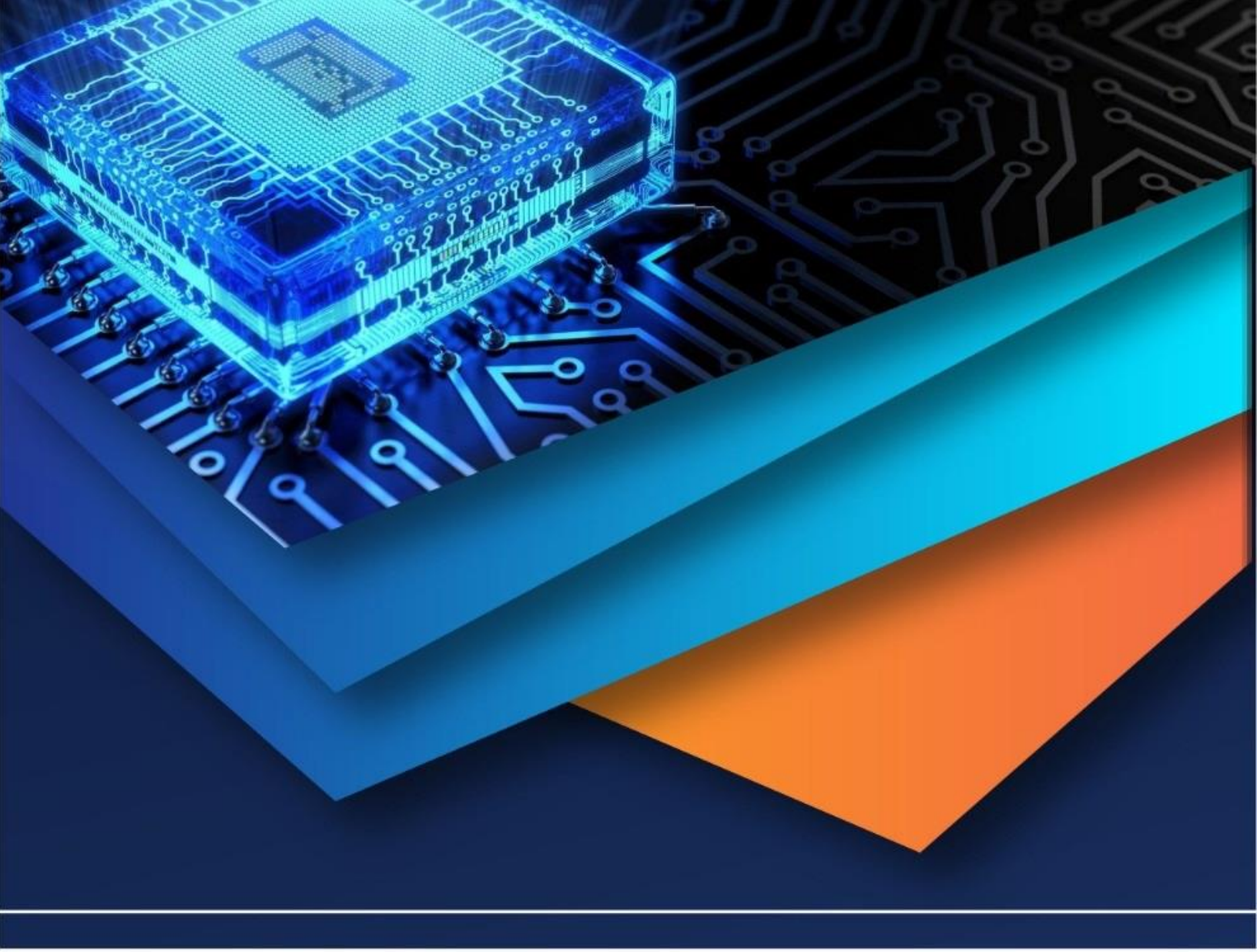

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