

Smart attendance management system with real-time sync and QR rotation

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Abstract: In educational institutions, attendance management plays a crucial role in monitoring student participation and academic performance. Traditional attendance systems such as manual registers and biometric devices suffer from several limitations, including time consumption, proxy attendance, lack of real-time monitoring, and operational inefficiency. To address these challenges, this project presents FSAS – a Smart QR-Based Attendance Management System, designed to provide a secure, efficient, and paperless solution for attendance tracking.

The proposed system replaces conventional methods with time-limited, dynamically generated QR codes that are displayed by professors during class sessions. Students scan the QR code using their mobile devices to mark their attendance in real time. To prevent fraudulent practices such as proxy attendance, the system incorporates multiple security mechanisms including QR code expiration, one-time scan validation, device fingerprinting, and optional geofencing to ensure physical classroom presence. Realtime updates are enabled using WebSocket communication, allowing faculty to monitor attendance instantly.

The system is developed using modern web technologies such as Next.js, TypeScript, Express.js, and Socket.IO, ensuring scalability, performance, and data security. It supports role-based access for students and professors, provides detailed attendance analytics, and enables report generation for academic review. The proposed solution enhances transparency, reduces administrative overhead, and improves the overall efficiency of attendance management in educational institutions. The system is flexible, secure, and suitable for real-world deployment in colleges and universities.

Keywords: Smart Attendance System, QR Code Attendance, Real-Time Attendance Tracking, Secure Attendance Management, Web-Based Attendance System, Next.js, Socket.IO

I.INTRODUCTION

1.1 Motivation:

The motivation for developing a smart attendance management system arises from the growing need for efficient, accurate, and secure attendance tracking in educational institutions. Traditional attendance methods such as manual registers are time-consuming, prone to human errors, and allow unfair practices like proxy attendance.

Even biometric-based systems, though automated, involve high installation costs, hardware dependency, hygiene concerns, and maintenance challenges, making them less flexible for modern academic environments. With the widespread use of smartphones among students, there is a strong opportunity to leverage mobile and web technologies to simplify attendance processes. QR code-based attendance systems offer a fast and convenient alternative. However, basic implementations often lack adequate security and can be easily exploited by sharing QR codes or marking attendance remotely. This creates a need for a more secure and intelligent solution that not only automates attendance but also preserves its authenticity.

1.2 Problem Statement

Educational institutions continue to rely on traditional attendance management methods such as manual roll calls and biometric systems, which present several operational and security challenges. Manual attendance recording consumes valuable classroom time, is prone to human errors, and allows proxy attendance, thereby affecting the accuracy and reliability of attendance records. Biometric systems, while automated, involve high infrastructure costs, require physical contact, and lack flexibility in handling real-time academic scenarios.

1.3 Objective of the Project:

- To prevent proxy attendance by using time-based QR code validation.
- To enable real-time synchronization of attendance data to the cloud.
- To provide secure and reliable attendance management for institutions.
- To offer easy monitoring and reporting for faculty and administrators.

- To store and manage attendance data efficiently using a centralized database.
- To provide real-time access to attendance records for students and faculty.
- To generate accurate reports for monitoring student attendance.
- To improve transparency and reliability in attendance management.

Scope:

The scope of this project is to develop and deploy a web-based smart attendance management system that can be effectively used in educational institutions to automate and secure the attendance process. The system focuses on the use of QR code technology combined with real-time validation to record attendance efficiently while preventing proxy attendance.

Project Introduction:

The FSAS project introduces a smart, secure, and efficient attendance management system designed to modernize the traditional process of recording student attendance in educational institutions. The system utilizes dynamically generated, time-limited QR codes that are displayed during class sessions and scanned by students using their mobile devices to mark attendance in real time. By integrating security mechanisms such as QR code expiration, one-time scan validation, device fingerprinting, and optional geofencing, the system ensures the authenticity and reliability of attendance records. The proposed solution provides real-time monitoring for faculty members, centralized data storage, and detailed attendance reports to track student participation effectively. Developed using modern web technologies, the system offers scalability, flexibility, and ease of use, making it a practical and reliable solution for improving attendance management and administrative efficiency in academic environments.

II. BACKGROUND

2.1 Smart QR- Based Attendance System Background

Smart attendance systems utilize digital identifiers and real-time communication to automate attendance recording. In QR-based attendance systems, a unique QR code is generated for each session and scanned by students using mobile devices. The system validates the scanned data against serverside session parameters before marking attendance. The process involves session initialization, QR code generation, validation checks, and database storage. Each attendance session operates within a defined time window to prevent reuse. The validation logic ensures that only authorized users can mark attendance during an active session, and the system maintains consistency by updating records in real time.

2.1 Future Applications:

The proposed Smart QR-Based Attendance Management System can be extended to various real-world applications beyond educational institutions. It can be effectively used in corporate offices for secure employee attendance tracking, eliminating the need for costly biometric systems. The system is also suitable for managing attendance in conferences, seminars, and workshops through quick QRbased check-ins. In addition, it can support hybrid and online learning environments by integrating virtual attendance validation with physical presence verification. The solution can further be applied in examination systems to prevent impersonation and ensure secure identity verification. In sectors such as healthcare and government organizations, it can assist in managing staff attendance with improved transparency and efficiency.

Future enhancements may include integration with artificial intelligence for attendance analytics and smart campus systems, enabling automation and advanced monitoring capabilities.

2.2 Aim of this study:

The aim of this project is to develop a secure, efficient, and real-time attendance management system using dynamic QR code technology. The system is designed to replace traditional attendance methods by minimizing manual effort, reducing errors, and preventing proxy attendance through advanced validation mechanisms. It focuses on ensuring accurate attendance recording by incorporating features such as time-based

QR code generation, one-time scan validation, device verification, and optional location-based checks. The project also aims to provide real-time monitoring and centralized data management, enabling faculty to track attendance seamlessly and generate reports effectively. Overall, the objective is to enhance transparency, reliability, and efficiency in attendance management within modern educational environments.

III.LITERATURE REVIEW

Related Work:

This section discusses the development of automated, secure, and technology-driven attendance management systems proposed by various researchers. Traditional manual attendance methods have been widely studied and criticized for being inefficient, time-consuming, and prone to proxy attendance. To overcome these issues, researchers have explored digital attendance solutions that leverage web technologies, mobile devices, and automated authentication mechanisms to improve accuracy and operational efficiency.

Early automated systems focused on reducing paperwork and minimizing classroom time spent on attendance

recording, but lacked sufficient security measures to prevent misuse. Several researchers have proposed QR code-based attendance systems to simplify attendance marking using smartphones. In these systems, instructors generate QR codes that students scan to record their presence. Studies indicate that QR-based systems are faster and more flexible than biometric solutions, as they do not require dedicated hardware installation. However, researchers also observed that static or reusable QR codes can be shared easily among students, enabling proxy attendance. This limitation has driven further research into dynamic and session-based QR code generation methods to enhance authenticity.

To address security concerns, recent studies have focused on integrating real-time validation techniques into attendance systems. These approaches validate attendance entries instantly by communicating with centralized servers, ensuring that each attendance record corresponds to an active session. Researchers reported that real-time validation improves transparency and enables faculty members to monitor attendance as it occurs. Despite these improvements, some systems still lack advanced verification mechanisms such as device level validation or contextual checks, which limits their effectiveness in preventing fraudulent attendance practices.

Mobile-based attendance systems have also been widely studied due to the widespread availability of smart phones. Researchers have demonstrated that mobile applications improve accessibility and user experience by allowing students to mark attendance using their own devices. However, studies emphasize that mobile-based solutions must incorporate strong authentication mechanisms to ensure reliability. Without proper validation, such systems remain vulnerable to unauthorized access and attendance manipulation.

Location-aware attendance systems using GPS and geo fencing technologies have been proposed to verify physical presence in classrooms. Research findings suggest that location-based validation can significantly reduce proxy attendance by restricting attendance marking to predefined geographic boundaries. However, limitations such as indoor GPS inaccuracy and privacy concerns have been reported. As a result, researchers recommend combining location-based techniques with other validation methods to improve robustness.

Role-based access control and centralized database management have also been emphasized in existing research. Studies highlight that assigning distinct roles to students and faculty enhances system security and prevents unauthorized operations. Centralized data storage enables consistent record keeping, report generation, and attendance analytics. Despite these advancements, existing

systems often fail to integrate all these features into a single, secure, and scalable solution, thereby motivating the development of a comprehensive smart attendance management system.

IV. Existing System

The existing attendance systems commonly used in educational institutions include manual attendance registers and biometric-based systems such as fingerprint or facial recognition devices. Manual attendance requires instructors to call roll numbers or circulate attendance sheets, which consumes valuable classroom time and is prone to human errors and proxy attendance. Biometric systems were introduced to automate this process and improve accuracy; however, they depend heavily on specialized hardware and require physical interaction. These systems often face issues related to maintenance cost, hardware failures, hygiene concerns, and limited scalability. Additionally, many existing digital attendance solutions lack real-time monitoring and flexibility, making them unsuitable for dynamic classroom environments and modern academic requirements.

V. Proposed System

The proposed system introduces A Smart QR-Based Attendance Management System designed to overcome the limitations of traditional attendance methods. The system replaces manual and biometric attendance with a time-limited, dynamically generated QR code for each class session. Faculty members initiate an attendance session, during which a QR code is generated and displayed. Students scan the QR code using their mobile devices, and attendance is marked only after successful real-time validation.

VII.SYSTEM DESIGN

Introduction of Input Design:

The workflow of the Smart QRBased Attendance System begins when the user (faculty) logs into the system and creates a new attendance session. Once the session is created, the system generates a unique QR code for that particular class. This QR code is displayed to students, and they use their mobile devices to scan the QR code. After scanning, the system performs real-time validation to verify the session details and ensure that the QR code is valid. If the verification is successful, the system records and validates the student's attendance automatically. The attendance data is then updated in the dashboard, where the faculty can view the attendance records in real time. Finally, after reviewing the attendance information, the user can logout from the system. This workflow ensures a secure, fast, and efficient method of recording attendance

while reducing manual effort and preventing proxy attendance.

Objectives for Input Design:

The objectives of input design are –

- To design efficient data entry and validation procedures.
- To reduce input errors and redundant data entry.
- To create user-friendly input forms and screens.
- To implement validation checks and input controls

Output Design:

Output design determines how processed information is presented to users. In the proposed system, outputs include attendance confirmation messages, attendance reports, dashboards, and analytics. Effective output design ensures that users receive accurate information in a clear and timely manner.

Objectives of Output Design:

The objectives of output design are:

- To provide outputs that meet user requirements.
- To present information in a clear and understandable format.
- To deliver outputs at the appropriate time.
- To support decision-making through reports and dashboards.

VIII.RESULTS

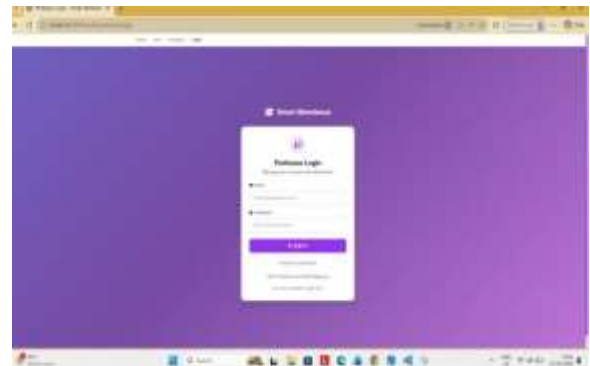
Home page:

The Home Page is the main interface of the Smart Attendance Management System. It provides options for both students and professors to access the system. From this page, users can either register or log in to their accounts. The system also supports real-time synchronization, meaning that attendance data is instantly updated and stored in the cloud database. This allows professors to view attendance records immediately and manage them efficiently. The home page acts as the entry point for all system functionalities.



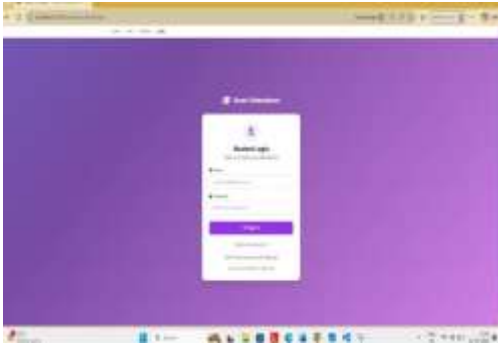
Login Page:

Professor Login Page is designed to provide secure access for faculty members to the Smart Attendance Management System. Professors can log in using their registered institutional email and password through a clean and user-friendly interface. The page includes input fields with proper validation to ensure correct data entry. Only authorized users are allowed access, maintaining system security. A Forgot Password option is available to help users recover their accounts. Additionally, new professors can register using the “Sign Up” link provided. In case of invalid credentials, appropriate error messages are displayed. Once successfully logged in, professors can manage classes, monitor student attendance, and perform administrative tasks. The layout is responsive and visually consistent with the system design. This module ensures secure, efficient, and role-based access for faculty users.



SS 1: PROFESSOR LOGIN PAGE

Student Login Page allows students to securely access the Smart Attendance Management System and interact with attendance features. Students are required to enter their registered institutional email and password to log in. The interface is simple, responsive, and easy to use, ensuring a smooth user experience. Input validation checks are applied to verify correct credentials before granting access. A Forgot Password option is available for account recovery in case users forget their passwords. New users can register through the Sign Up link, while a separate link is provided for professors to navigate to their login page. Error messages are shown when incorrect details are entered, helping users correct mistakes. After successful login, students can mark their attendance and view their records. The page design maintains consistency with the overall system theme. This module acts as the primary access point for student-related functionalities in the system.



SS2: STUDENT LOGIN PAGE

User Dashboard:

The Professor Dashboard is the main interface that appears after a professor successfully logs into the Smart Attendance Management System. It provides an overview of important information such as total classes, total students, and active sessions. The dashboard displays the current date and time along with a welcome message for the professor. A sidebar menu allows easy navigation to sections like Dashboard, My Classes, Sessions, and Profile. The system also includes a notifications panel where professors can view updates such as class sessions started, attendance marked, and report generation. An option to create a new class is available at the top of the dashboard. The “Today’s Classes” section shows the schedule for the current day. This page helps professors quickly monitor and manage their teaching activities. It improves usability by organizing key data in a clear and structured layout. Overall, the dashboard acts as the central control panel for managing attendance and class-related operations.



SS3: PROFESSOR DASHBOARD

The Student Dashboard of the Smart Attendance System, designed to give students a quick overview of their attendance-related activity. It welcomes the logged-in student personally and displays the current date and time. The dashboard contains summary cards showing key daily attendance metrics such as Today’s Scans, Present, Late, and Absent. A sidebar navigation menu provides access to major sections including Dashboard, My Classes, Scan QR, Attendance, and Profile, allowing students to move easily through the system. At the top, a Scan QR button is

provided for marking attendance through QR-based scanning. The dashboard also includes a Quick Stats section showing the total number of classes and average attendance, along with a Today’s Classes panel that informs the student about scheduled classes for the day. In the displayed example, no classes are scheduled. This screen is intended to give students a simple and efficient way to monitor their attendance status and access important academic functions.



SS4: STUDENT DASHBOARD

IX. CONCLUSION

This project presents an effective and practical solution for modernizing attendance management in educational institutions through the development of a Smart QR-Based Attendance Management System. By replacing traditional manual and biometric attendance methods with a secure, real-time QR-based approach, the system significantly improves accuracy, efficiency, and reliability. The proposed system utilizes time-limited QR codes, real time validation, and centralized data management to eliminate proxy attendance.

The implementation demonstrates that attendance can be recorded quickly and securely using widely available mobile and web technologies without the need for additional hardware. Extensive testing and validation confirm that the system performs reliably under various conditions and meets both functional and non-functional requirements. The system is scalable, userfriendly, and adaptable to different academic environments, making it suitable for realworld deployment in colleges and universities. Overall, this project addresses the growing need for efficient and secure digital attendance solutions and contributes to the advancement of academic administration systems in an increasingly technology-driven educational landscape.

X.FUTURE ENHANCEMENT

Future enhancements of this project will focus on expanding the functionality, security, and scalability of the Smart QRBased Attendance Management System to meet evolving academic and technological requirements. While

the current system effectively automates attendance using timelimited QR codes and real-time validation, further improvements can enhance its adaptability across diverse educational environments. Future work aims to integrate advanced technologies that improve accuracy, user experience, and system intelligence while maintaining efficiency and security.

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