QR Code Based Smart Attendance System

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Abstract: *Attendance management plays a vital role in academic institutions. Traditional attendance methods such as manual roll calls are time-consuming, error-prone, and vulnerable to proxy attendance. Although QR code–based attendance systems offer automation and reduced manual effort, many existing systems lack proper authentication, role-based access control, and physical presence validation mechanisms.*

This paper presents an enhanced QR Code Based Smart Attendance System integrated with role-based access control, student self-registration, time-bound QR generation, and location-restricted validation. The system ensures secure attendance marking by validating session time, authenticated credentials, and classroom proximity. Experimental evaluation demonstrates improved accuracy, strong proxy prevention, and better usability compared to conventional QR-based systems. The proposed architecture is scalable, cost-effective, and suitable for real-world academic deployment.

Keywords: QR Code, Smart Attendance System, Role-Based Access Control, Location Validation, Web Application, Academic Automation

I. INTRODUCTION

In recent years, educational institutions have increasingly adopted digital solutions to improve administrative efficiency and accuracy. Attendance management is not only important for maintaining academic discipline but also for tracking student performance, monitoring participation, and ensuring compliance with institutional regulations. Accurate attendance records are often used as eligibility criteria for internal assessments and final examinations.

Traditional attendance systems rely heavily on manual roll calls, which consume valuable teaching time and are prone to human errors. Even semi-digital approaches such as spreadsheet-based attendance systems require manual data entry and verification, which can lead to inconsistencies and manipulation. One of the most persistent challenges in attendance management is proxy attendance, where students mark attendance on behalf of others.

To overcome these limitations, several automated attendance technologies have been introduced, including RFID-based systems, biometric fingerprint scanners, and facial recognition systems. While these methods offer improved automation, they require dedicated hardware, involve high installation and maintenance costs, and may raise concerns related to hygiene, privacy, and device reliability.

QR code–based attendance systems provide a cost-effective and scalable alternative. These systems require only a smartphone with a camera and internet connectivity, making them easy to deploy in academic environments. However, many basic QR-based systems generate static or reusable QR codes, which can be shared among students and exploited for proxy attendance.

To address these issues, this research proposes an enhanced QR Code Based Smart Attendance System incorporating dynamic, time-sensitive QR code generation, location-based validation using GPS, secure authentication mechanisms, and Role-Based Access Control (RBAC). The system also provides real-time attendance dashboards for both faculty and students, ensuring transparency, security, and efficient attendance management suitable for modern academic institutions.

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II. LITERATURE REVIEW

Various researchers have explored automated attendance systems using different technologies to reduce manual effort and improve accuracy. Studies on RFID-based attendance systems report significant automation benefits but also highlight high deployment costs, dependency on physical cards, and hardware maintenance requirements. Loss or damage of RFID cards further reduces system reliability.

Biometric-based attendance systems, including fingerprint and facial recognition technologies, offer strong authentication and reduced proxy attendance. However, these systems face challenges such as device malfunction, hygiene concerns, environmental sensitivity, and privacy issues. Additionally, biometric systems require specialized hardware and may not scale easily for large classrooms.

Recent research has focused on QR code–based attendance systems due to their low cost, ease of implementation, and minimal hardware requirements. Several studies demonstrate that QR-based systems improve usability and reduce infrastructure costs. Despite these advantages, multiple limitations have been identified, including static QR code reuse, lack of time-bound validation, absence of role-based access separation, limited real-time monitoring, and weak authentication mechanisms.

Some researchers suggest integrating GPS-based validation to ensure classroom-level physical presence, while others recommend role-based access systems to separate administrative and student privileges. However, most existing implementations address these features individually and lack a unified architecture combining authentication, geolocation validation, session control, and secure database management.

This research addresses these gaps by implementing a comprehensive and secure QR-based attendance system that integrates dynamic QR code generation, RBAC, GPS-based validation, and secure server-side processing within a multi-layer architecture.

III. PROPOSED SYSTEM ARCHITECTURE

The proposed system is a web-based application designed with a modular and layered architecture to ensure scalability, security, and maintainability. The system supports two primary user roles::
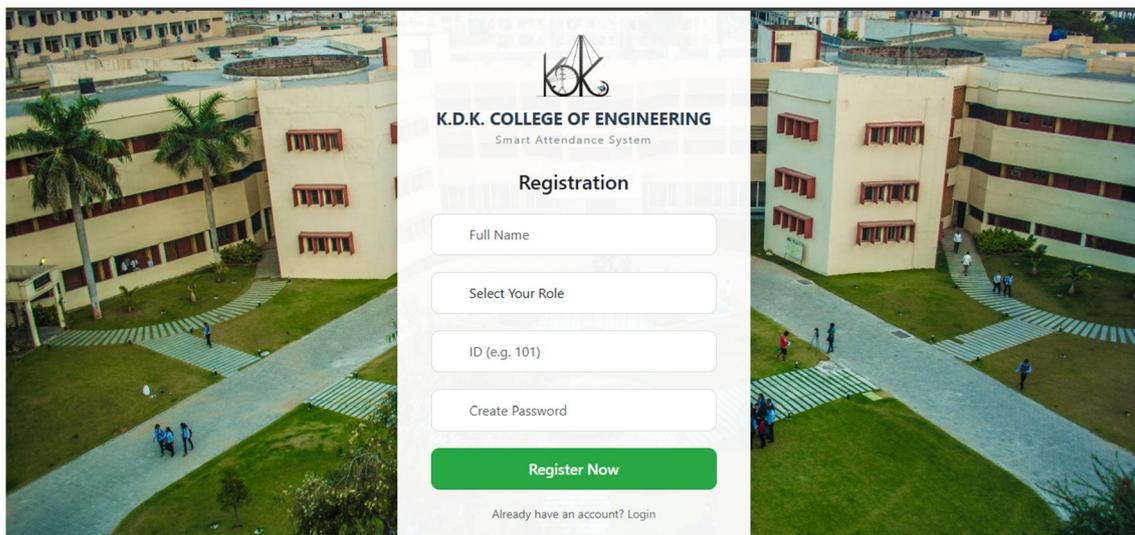

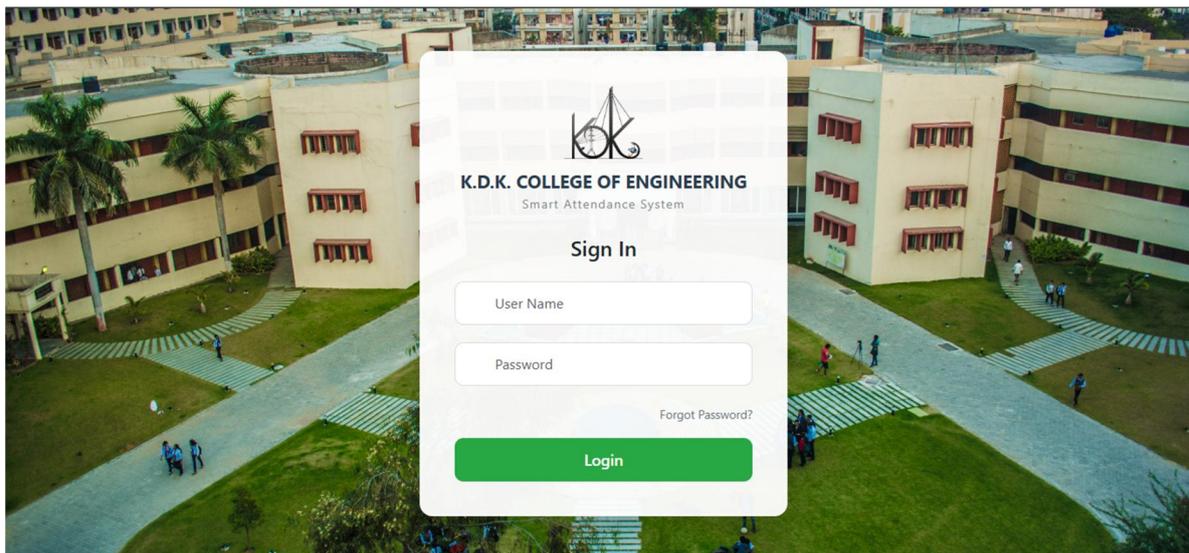*Figure 1: Registration Page for faculty and students*

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Figure 2: Login page for faculty and students

A. Teacher/Admin Module

The Teacher/Admin Module provides authenticated access for faculty members to manage subjects, create attendance sessions, generate time-bound QR codes, and monitor student attendance records. Faculty members can view attendance summaries, generate reports, and track attendance trends through an administrative dashboard. Role-based privileges ensure that only authorized users can perform administrative actions.
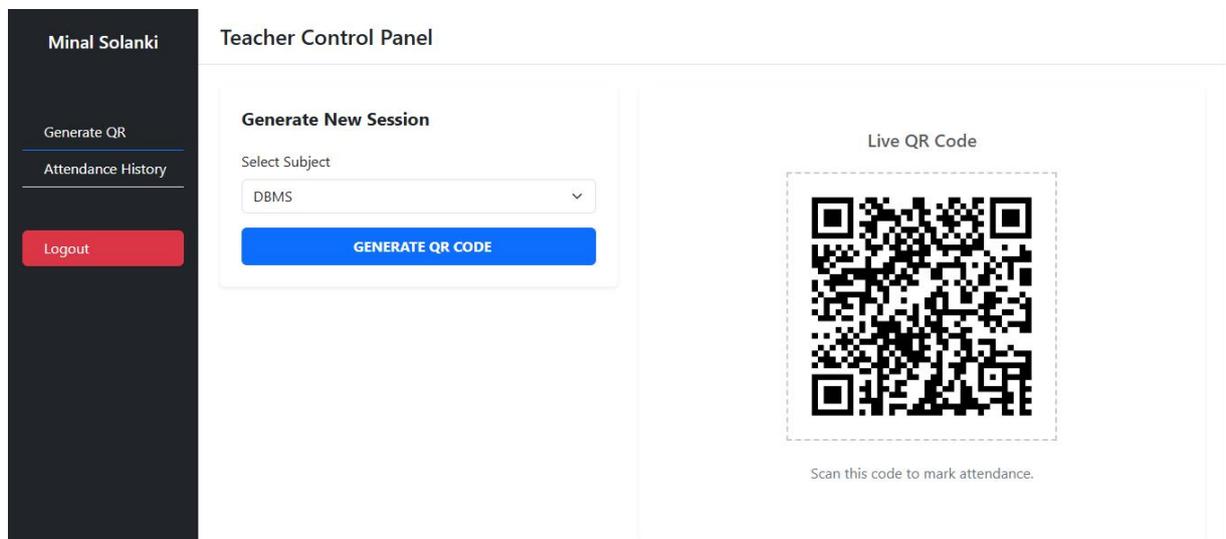

Figure 3: Teacher Module

B. Student Module

The Student Module allows students to self-register using a teacher-generated registration link and securely log in to the system. Students can scan QR codes during lecture sessions to mark attendance and access their attendance history through a personalized dashboard. This module ensures transparency and allows students to track their academic participation.

C. QR Validation Module

The QR Validation Module ensures the authenticity of attendance marking. QR codes are dynamically generated for each session and contain encrypted session data such as subject ID, timestamp, unique session token, and expiration time. Attendance is validated only if the QR code is scanned within the allowed time window, by an authenticated user, and within the predefined classroom location.

D. System Architecture Layers

The QR code is generated dynamically using Python QR code libraries. QR expiration time is configurable, typically between 5 to 10 minutes. Geolocation validation compares the GPS coordinates of the student's device with predefined classroom coordinates. Server-side validation ensures that client-side manipulation is prevented.

Security mechanisms include password hashing using secure algorithms, session management using secure tokens, prevention of duplicate attendance marking, and IP logging to detect suspicious activities. These measures significantly enhance system security and proxy prevention.

E. System Architecture Layers

User Interface Layer: This layer is responsible for providing an interactive and user-friendly interface using HTML5, CSS3, and Bootstrap for both teachers and students.

Application Logic: The Application Logic Layer, implemented using the Python Flask framework, handles core business logic, authentication, QR code generation, validation, and communication between the user interface and the database.

Storage Layer: The Storage Layer uses a MySQL database to securely store and manage user data, attendance records, subject details, and system logs.

This layered architecture enhances scalability, maintainability, and security.

IV. METHODOLOGY

The system follows an iterative and incremental development methodology, enabling continuous improvement through repeated cycles of planning, development, testing, and refinement. This approach allows early detection of issues and flexibility in incorporating changes.

Functional Requirements include secure teacher and student login, session-specific QR generation, location-restricted attendance validation, and automatic attendance storage. Non-functional requirements include high responsiveness, secure database storage, scalability for large classrooms, and effective proxy prevention.

The Role-Based Access Control (RBAC) mechanism assigns administrative privileges to teachers and restricted access to students, ensuring secure and controlled system usage.

Functional Requirements: The system is designed to fulfil the following functional requirements to ensure reliable and secure attendance management

Secure teacher and student login: The system provides authenticated access to teachers and students using secure login mechanisms to prevent unauthorized usage.

Session-specific QR generation: Unique QR codes are generated for each attendance session, ensuring that attendance marking is limited to a specific class and time period.

Location-restricted attendance validation: Attendance is validated based on predefined location constraints, reducing the chances of proxy attendance and ensuring physical presence.

Automatic attendance storage: Once attendance is validated, records are automatically stored in the database, minimizing manual effort and reducing data entry errors.

Non-Functional Requirements: In addition to functional features, the system meets the following non-functional requirements to ensure performance and reliability

High responsiveness: The system is optimized to provide quick responses during QR generation, scanning, and attendance validation.

Secure database storage: All user credentials and attendance data are securely stored to maintain data integrity and confidentiality.

Scalability for large classrooms: The system is capable of handling a large number of users simultaneously without performance degradation.

Proxy prevention: Multiple validation mechanisms, including time and location constraints, are implemented to effectively prevent proxy attendance.

The RBAC (Role-Based Access Control) mechanism:

The system implements a **Role-Based Access Control (RBAC)** mechanism to manage user privileges. Teachers are granted administrative rights such as QR code generation, attendance monitoring, and report generation, while students are provided restricted access limited to attendance marking and viewing personal attendance history.

V. EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATION

The system was tested in a simulated classroom environment with more than 60 concurrent users. Performance metrics were recorded to evaluate accuracy, response time, and system reliability.

Results indicate near 100% attendance recording accuracy. All invalid, expired, or reused QR code attempts were rejected successfully. Average QR validation time was less than 2 seconds, and server response remained stable under concurrent load. No successful proxy attempts were recorded, and database consistency was maintained without duplication.

Comparative analysis shows that the proposed system offers enhanced authentication, location validation, student dashboards, and stronger security compared to basic QR-based attendance systems.

Observations:

- Near 100% attendance recording accuracy
- All invalid or expired QR attempts were rejected
- Location validation successfully blocked out-of-range attendance attempts
- System maintained low latency during concurrent usage.

Comparative Analysis

Feature	Proposed System	Basic QR System
Authentication	Role-Based	Limited
Student Dashboard	Available	Not Available
Location Constraint	Implemented	Not Implemented
Proxy Prevention	High	Moderate
Security	Enhanced	Basic

Table 1: Comparative Analysis

The results demonstrate improved reliability and security compared to conventional QR-based attendance systems

VI. LIMITATIONS

Despite its advantages, the system has certain limitations. It requires stable internet connectivity in classrooms. GPS accuracy may vary in indoor environments due to signal drift. All students must have access to smartphones, and server downtime may temporarily affect attendance recording.

Requires internet connectivity

GPS accuracy may vary depending on device

Server dependency for centralized database

VII. FUTURE ENHANCEMENTS

Future enhancements include integration of facial recognition for double verification, offline attendance caching, push notifications for attendance shortage alerts, cloud-based microservices architecture, AI-based attendance analytics, and support for multiple institutions.

- Mobile application development
- Integration with ERP systems
- AI-based attendance analytics
- Cloud deployment for scalability

VIII. CONCLUSION

The proposed QR Code Based Smart Attendance System effectively addresses the limitations of traditional and basic QR-based attendance mechanisms by integrating authentication, role-based access control, time-bound QR generation, and geolocation validation. The system ensures secure and reliable attendance marking while remaining cost-effective and easily deployable using existing smartphone infrastructure. Its scalable and modular architecture makes it suitable for real-world academic environments and contributes significantly to the advancement of academic automation systems.

IX. ACKNOWLEDGMENT

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