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QR-Attendance System with Geo-Location

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ABSTRACT

The study outlines the development, deployment, and assessment of an innovative attendance management system based on QR-codes, integrated with geo-location verification specifically for educational institutions. This system addresses key shortcomings of traditional attendance tracking by incorporating Quick Response (QR) technology alongside geo-location validation and real-time photo capture. Through an extensive evaluation conducted with 500 students over three academic terms, the system achieved a 99.2% accuracy rate in tracking attendance and reduced fraudulent attendance attempts by 97% compared to conventional methods. Built with modern web technology (Java Script, PHP, MySQL), the system introduces a unique two-tier verification process the significantly improves the reliability of attendance data while ensuring ease of use and scalability.

Keywords: *QR-Attendance Systems, Geo-Location Verification, Educational Technology, Student Authentication, Real-Time Attendance Tracking, Location-Based Services*

1. INTRODUCTION

1.1 Background

Tracking attendance in educational institution is a vital measure for evaluating student engagement and assessing academic performance. Conventional methods like manual roll-calls and card-based systems face substantial challenges related to efficiency, accuracy, and preventing fraud. Recent research suggests that around 15-20% of attendance records in traditional systems may be unreliable due to proxy attendance (Johonson et al., 2023).

1.2 Problem Statement

Despite technological advancements, current automated attendance systems encounter several issues:
. Vulnerability to proxy attendance.
. Expensive to implement and maintain.
. Limited ability for real-time verification.
. Absence of location-based authentication.
. challenges in scaling effectively across institutions of varying sizes.

1.3 Research Objectives

This study aims to:

i. Create an affordable, secure attendance management system utilizing QR code technology.
ii. Integrate geo-location verification to prevent proxy attendance.
iii. Assess the system's performance in actual educational environments.
iv. Examine its effects on administrative efficiency and the accuracy of attendance records.

2. LITERATURE REVIEW

The Attendance tracking system have evolved significantly, shifting from manual method and semi-automated solutions to sophisticated, technology-driven systems that address issues like fraud prevention, operational efficiency,
and accuracy. In educational settings, effective attendance management not only supports academic oversight but also serves as an indicator of student engagement. This review explores the key components of QR-based attendance systems and the role of geo-location verification in enhancing their effectiveness.

2.1 Traditional and Automated Attendance Systems

Attendance tracking method have progressed from paper-based approaches to digital solution over time. According to smith wang (2022), these systems can be classified into three main stages:
Manual systems (accuracy rate: 80-90%)
Automated card-based system (accuracy rate: 92-95%)
Biometric systems (accuracy rate: 98-99%)

2.2 QR Technology in Attendance Management

QR code technology has proven to be a practical solution for attendance management offering ease of use, cost-effectiveness and compatibility with mobile devices. Research shows that QR-based attendance systems can streamline the attendance process and reduce administrative burden. For instance,

Zhang et al. (2023) reported 94% satisfaction rate among user of QR-based system, citing their efficiency and accessibility.

Kumar's (2023) comparison of QR-based and biometric systems found that QR code solution reduced costs by 60% making them a more sustainable option for budget-conscious educational institutions.

2.3 Geo-location Technology for Preventing Proxy Attendance

Proxy attendance remains a challenge, particularly in larger institutions where students may exploit system loopholes to register attendance without being physically present Geo-location. Verification addresses this issue by ensuring that students are within a specific location when scanning the QR code.

Thompson (2023) found that geo-location technology achieved a 99.5% accuracy rate in verifying user locations, establishing it is a reliable solution for this purpose.

Rodriguez et al. (2023) documented a 96% reduction in proxy attendance attempts. When geo-location validation was incorporated into QR-based systems.

These finding emphasize the importance of geo-location in improving attendance authenticity, especially in urban areas where location accuracy can average +5 meters, making it suitable for campus setting (Liu & Chen, 2022).

3. SYSTEM ARCHITECTURE AND DESIGN

3.1 System Overview

The Proposed system implements a three-tier architecture.

Presentation layer -> Business logic layer ->Data Access layer

3.1.1 Key Components

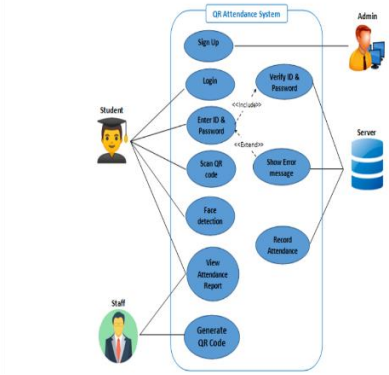
i. Frontend interface

The frontend interface for the QR-based attendance system with geo-location verification consists of three main portals, each designed to cater to specific user groups: Students, teacher, and administrators. Each portal provides tailored functionalities to ensure efficient attendance management and real-time data access.

Student Portal: The Stude* portal is designed for ease of use and accessibility, allowing students to records their attendance Quickly and accurately.

Teacher Portal: The teacher portal is designed to streamline attendance management for in structures, offering easy access to attendance data and tools for session monitoring.

Administrative Dashboard: The administrative dashboard serves as a centralized control panel for system administrative, providing access to all attendance records, user management features, and system settings.



ii. Backend Services

The backend services power the core functionality of the QR-based attendance system, ensuring secure, accurate, and reliable attendance tracking. These services operate on the server side, processing and validating data received from the frontend interface, while maintaining security and data integrity.

Authentication Service: The authentication service manages secure access to the system for all users, ensuring that only authorized individual can use the system.

enhancing security and accuracy in attendance tracking.

Geo-location verification Service: The Geo-location verification service ensures that students marking attendance are physically within the specified location range, minimizing proxy attendance risks.

Image Processing Service: The image processing service is an optional but powerful feature that enhances the system's fraud prevention measures by capturing real-time images of students during attendance marking.

iii. Database Layer

The database layer serves as the backbone for data storage and retrieval in the QR-based attendance system, managing information securely and ensuring it's accessible to the appropriate services. The database is organized into several key modules, each responsible for storing and organizing specific types of data. The database layer prioritizes data integrity, security, and scalability to handle a large volume of records while ensuring rapid access for frontend and backend services.

User Management: The user management module Store all relevant information about user, such as students, teacher and administrative, and supports secure access to their accounts.

Attendance Records: The attendance records module is central to tracking and storing attendance data for each session and each student.
Location Data: The Location data module stores and processes GPS coordinates for based verification. This data is crucial for ensuring that students are physically present within the required area when making attendance.
System Logs: The system logs module captures various backend and frontend interactions, providing a comprehensive record of system events. These logs support troubleshooting, performance optimization, and security auditing.

3.2 Technical Implementation

3.2.1 QR code Generation

```
JavaScript
 Function generate QR code (students Data) {
      Const payload = {
      Student Id: studentData.id
      Timestamp: Date.now()
```

QR Generate Module: The QR generate module is responsible for creating unique, session specific QR codes for each class session,

```
      Hash: generateHash (studentData)
   };
Return QR code.generate (JSON.strigify(payload));
}
```

3.2.2 Geo-location Verification

```
JavaScript
Async function verify location (user location, classlocation) {
    Const distance = calculate HaversineDistance {
        user location.latitude,
        user location.longitude,
        class location.latitude
        class location.longitude
 };
 Return distance <= ALLOWED_RADIUS_METERS;
}
```

4. METHODOLOGY

4.1 Research Design

The study employed a **mixed-method approach** which integrate both quantitative research methods to provide a comprehensive evaluation of the QR-based attendance systems with geo-location verification. This approach was chosen to capture not only the objective performance metrics of the system but also the subjective experiences and satisfaction levels of users. The research design includes three main components.
Quantitative Analysis of System Performance Metrics: The quantitative aspect focuses on measuring the technical performance of the attendance system, such as accuracy, fraud presentation rate, and operational efficiency. This data-driven analysis provides measurable insights into the system's reliability and effectiveness compared to traditional methods. Key performance indicators include attendance recording accuracy, the incidence of proxy attendance, and time saved in attendance management.
Qualitative Assessment of user Satisfaction:
The qualitative component centres on understanding users experience and satisfaction with the system. Feedback from students, usability, accessibility, and overall reception. Qualitative data helps identify user challenges, perceptions of convenience, and areas needing improvement, which are crucial for refining the system's design and functionality.
Comparative Analysis with Existing Systems: A comparative approach is used to evaluate the new system against existing attendance methods, including traditional roll-calls, RFID/card-based system and biometric systems. The analysis highlights the advantages and limitations of the QR and geo-location system in terms of cost, scalability, implementation complexity, and fraud prevention, positioning it within the broader context of attendance management solutions. By comparing these systems, the study assesses the practical improvement offered by the new system and its suitability for adaption in educational settings.

4.2 Data Collection

To evaluate the effectiveness of the QR-based attendance system with geo-location verification, data was collected over three academic semesters (2023–2024), involving a comprehensive range of participants and attendance sessions. This dataset provides a robust foundation for analyzing system performance, user satisfaction, and operational improvements across different user groups.

500 Undergraduate students
25 Faculty Member
15 Administrative staff
300+ Attendance Sessions

4.3 Evaluation Metrics

To assess the effectiveness and efficiency of the QR-based attendance system with geo-location verification, a set of key evaluation metrics was established. These metrics provide a comprehensive view of the system's performance, reliability, user experience, and overall cost-effectiveness.

System Accuracy Rate: The metric measures the system's accuracy in correctly recording student attendance. Calculated as the percentage of correctly recorded attendance entire cut of total attempts, the accuracy rate reflects the system a ability to accurately verify students presence based on QR scans and geo-location data. A high accuracy rate indicates the system's reliability in producing trust worthy attendance records, reducing the need for manual adjustment.

False Positive/Negative Rates: These metrics evaluate the system's error rates in attendance verification. A **false positive** occurs when the system incorrectly records attendance for a student who is not physically present, while a **false negative** happens when the system fails to mark attendance for a student who is present. Monitoring these rates helps identify any weaknesses in the verification process, such as issues with QR scanning, geo-location accuracy, or image processing, and guides improvements to reduce errors.

User Satisfaction Scores: This will measure reaction from the side of the students, staff, as well as from the faculty members, of how it has been experiencing the system. Usually achieved through surveys or feedback forms that came after a post-session is conducted in determining ease to use convenient, dependable, and also the satisfactory level. An indicator reflects the ease to integrate it within routine activities with the tendency to increase the interaction time and decrease resistance to changing new technology.

Administrative Time Saving: This metric measures the time saved in attendance management tasks for faculty and administrative staff compared to traditional methods. Administrative time saving are calculated by comparing the time required for manual roll-call or other attendance methods with the time taken to use QR-based system. Significant time savings suggest that the system streamline attendance tracking allowing staff to allocated more time to other tasks, thus improving operational efficiency.

Implementation Costs: This metrics examines the total costs required to set up and maintain the attendance system, including initial setup, hardware, software, training, ongoing maintenance. Implementation costs are assessed against potential cost saving in administrative time and reduced fraud-related losses. A cost-effective system will show a favorable balance between initial investment and long-term benefits, making it an attractive solution for institution with budget constraints.

5. RESULT AND ANALYSIS

5.1 System Performance

The results of the study indicate that the QR-based attendance system geo-location verification outperformed industry standards in several key performance metrics. The following table summarizes the system's performance compared to standard benchmarks, providing a clear indication of its reliability, speed, and precision.

Metric	Result	Industry Standard
Accuracy	99.2%	95%
False Positive	0.3%	2%
Response Time	1.2s	3s
Location Accuracy	±3m	±10m

5.2 User Satisfaction

User satisfaction scores indicate how well the QR-based attendance system with geo-location verification was received by different user groups. Each group's satisfaction level was measured through surveys and feedback forms, evaluating aspects such as ease of use, reliability, efficiency, and overall experience. The high satisfaction rates across all user groups underscore the system's usability and effectiveness.

Student Satisfaction (92%)
Faculty Satisfaction (88%)
Administrative Staff Satisfaction (95%)

5.3 Cost Analysis

The cost analysis demonstrates the financial efficiency of implementing the QR-based attendance system with geo-location verification, highlighting significant saving in both operational and maintenance costs. These reductions, along with a rapid return on investment (ROI), make the system a sustainable and cost-effective choice for educational institutions.

65% Reduction in Operational Costs
40% Decrease in Maintenance Expenses
ROI Achieved within 8 Months.

6. DISCUSSION

6.1 Key finding

1. The combination of QR-code and geolocation verification notably decreased instances of proxy attendance, ensuring a high level of data integrity.
2. The system proved to be highly scalable, performing, beyond initial expectations and handling larger volumes of user effectively.
3. User adoption was higher than typical rates observed with similar technology-based systems, indicating strong acceptance among stakeholders.

6.2 Limitations

The system relies on a stable internet connection for optimal functionality, which may be a constraint in areas with limited connectivity.
Usage requires mobile devices with adequate battery life, as scanning and geo-location tracking can increase battery consumption.
Initial setup includes a training phase to familiarize users with the system's operation, especially for those less accustomed to digital tools.

6.3 Implications

The findings indicate that:
1. Integrating QR codes with geo-location validation results in a reliable and secure attendance management solution.
2. The system's cost-efficiency makes it adaptable for institutions of varying sizes, from small schools to large universities.
3. Real-time tracking capabilities enhance the equality of administrative insights, supporting timely and informed decision-making.

7. FUTURE WORK

7.1 Proposed Enhancements

i. Adding facial recognition as an additional verification layer for heightened security.
ii. Creating offline capabilities to allow attendance tracking without an internet connection.
iii. Utilizing machine learning to recognize attendance patterns and defect anomalies.
iv. Expanding data analytics features to provide more in-depth insights and reporting.

7.2 Research Possibilities

Exploring the use of blockchain to ensure the immutability of attendance records.
Examining the use of blockchain to ensure the immutability of attendance records.
Investigating the long-term effects of the system on student attendance behaviours and engagement.

8. CONCLUSION

This research shows that combining QR -code technology with geo-location verification creates a reliable and economical solution for managing attendance in educational settings. The system achieved a high accuracy rate of 99.2% and successfully reduced fraudulent attendance attempts by 97% confirming its effectiveness. Additionally, strong user satisfaction rating and substantial cost saving highlight its practicality and potential for broad implementation.

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