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# Automated Attendance and Analytical System using QR Code And Mern Stack

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***Abstract:*** This paper presents the design and implementation of an Automated Attendance and Analytical System that leverages QR code technology integrated with the MERN stack (MongoDB, Express.js, React.js, Node.js). Traditional manual attendance methods are time-consuming, error-prone, and lack real-time analytical insights. The proposed system enables students to mark attendance by scanning dynamically generated, session-bound QR codes, while administrators and faculty gain access to a real-time analytics dashboard. The frontend is built using React.js and Tailwind CSS, ensuring a responsive and intuitive interfac e across devices. The backend is powered by Node.js and Express.js, with MongoDB serving as the primary database. A pilot conducted over six weeks with 120 students demonstrated 99.2% attendance recording accuracy, an average scan response time of 142 ms under concurrent load, and significant reduction in administrative overhead. The results confirm the viability of the proposed system as a scalable, hardware-free replacement for conventional attendance processes.

***Keywords:*** QR code attendance; MERN stack; automated attendance system; React.js; Node.js; MongoDB; web application;attendance analytics; real-time dashboard; anti-proxy attendance

## I. INTRODUCTION

Attendance management is a fundamental administrative function in educational institution. Conventional processes – roll call, sign-in sheets introduce delays, transcription errors, and opportunities for proxy attendance. With the widespread availability of smartphones and high-speed wireless connectivity, technology-driven solutions have become both practical and cost-effective.

QR (Quick Response) codes have emerged as a reliable, contactless mechanism for rapid data exchange. When integrated into a web application, they provide a scalable means of recording attendance without requiring specialized hardware. This paper proposes an Automated Attendance and Analytical System that combines session-bound QR code check-ins with real-time analytics, built entirely on open-source, industry-standard technologies of the MERN stack.

The objectives of this system are: (i) to eliminate manual attendance processes; (ii) to prevent proxy attendance through time-expiring, session-specific QR codes; (iii) to provide faculty and administrators with actionable analytics; and (iv) to ensure the solution is lightweight, cross-platform, and maintainable without proprietary infrastructure.

The remainder of this paper is organized as follows: Section II reviews related work. Section III describes the system architecture. Section IV presents the methodology. Section V reports experimental results and analysis. Section VI concludes the paper and outlines future research directions.

## II. RELATED WORK

### A. *Traditional Attendance Systems*

Manual attendance systems remain prevalent in many institutions despite well-documented limitations. Roll call consumes 3–5 minutes of lecture time per session and is susceptible to proxy marking. Paper-based registers introduce transcription errors and require significant manual effort for aggregation and reporting [1].

RFID-based systems offer contactless attendance but require dedicated reader infrastructure and are vulnerable to card sharing [2]. Biometric fingerprint and iris recognition systems achieve high accuracy but involve considerable hardware investment and raise privacy concerns [3].

### B. *QR Code and Mobile-Based Approaches*

QR code-based systems have gained attention due to their accessibility. Smartphones capable of scanning QR codes are ubiquitous, eliminating the need for specialized

readers. Nath et al. [4] demonstrated a QR-based campus check-in system; however, that work lacked a comprehensive analytics component and was not built on modern full-stack JavaScript frameworks.

Mobile-based NFC attendance systems have also been explored but are limited by the short communication range of NFC and the requirement for NFC-enabled devices on both ends [5]. Location-based check-in using GPS has been proposed but is unreliable indoors and is susceptible to GPS spoofing.

### *C. Web Application Frameworks for Academic Systems*

The MERN stack (MongoDB, Express.js, React.js, Node.js) has emerged as a dominant choice for building modern web applications due to its JavaScript-only programming model, non-blocking I/O, and rich ecosystem. Prior academic management systems built on PHP/MySQL stacks [6] have gradually been superseded by MERN-based solutions that offer superior real-time capabilities through Socket.IO and seamless JSON data exchange between layers. The present work builds on this foundation and extends it with QR-driven attendance capture and integrated analytics.

## III SYSTEM ARCHITECTURE

The system follows a three-tier client-server architecture comprising the Presentation Layer, Application Layer, and Data Layer, as summarized in Table 1.

***Table 1 System Architecture Overview***

| Layer Component | Technology |
|---|---|
| Frontend UI | React.js, Tailwind CSS, JavaScript |
| QR-Code Scanning | react-qr-reader (device camera) |
| Backend API | Node.js, Express.js (RESTful) |
| Real-time Updates | Socket.IO (WebSocket) |
| Authentication | JSON Web Tokens (JWT) |
| QR Generation | qrcode (npm) |
| Database | MongoDB with Mongoose ODM |
| Deployment | Node.js server, MongoDB Atlas |

### *A. Presentation Layer (Frontend)*

The frontend is developed using React.js with functional components and React Hooks for state management. Tailwind CSS provides a utility-first styling framework ensuring responsiveness across desktop and mobile devices. Three primary portals are exposed: (i) Student Portal with QR scanner interface using the device camera; (ii) Faculty Dashboard for session management, QR code generation, and live attendance monitoring; and (iii) Admin Analytics Panel displaying attendance trends, absentee reports, and course-level statistics.

### *B. Application Layer (Backend)*

The backend is implemented using Node.js and Express.js, exposing a RESTful API secured by JSON Web Tokens (JWT). Role-based access control distinguishes between student, faculty, and admin roles. Session-specific QR codes are generated using the qrcode npm library and expire after a configurable window (default: 5 minutes) to prevent code forwarding. Real-time attendance updates are pushed to connected faculty dashboards via Socket.IO WebSocket connections.

### *C. Data Layer (Database)*

MongoDB, a NoSQL document store, persists all application data. Mongoose ODM enforces schema validation and provides an expressive query interface. Collections include Users, Courses, Sessions, and AttendanceRecords. Compound indexes on sessionId and studentId fields ensure sub-millisecond lookup performance.Optional geolocation bounding per session is stored as GeoJSON for location-based proxy prevention.

## IV METHODOLOGY

The project followed an Agile development methodology with two-week sprint cycles. The end-to-end QR attendance workflow proceeds as follows:

1. Faculty initiates a class session; the backend generates a unique, time-bound, signed QR token.
2. The QR code is displayed on the faculty's screen or projected in the classroom.
3. Students open the Student Portal and scan the QR code using their smartphone camera.
4. The backend validates the token signature, checks expiry, and verifies the student's enrollment in the course.
5. A successful validation writes an Attendance Record document to MongoDB with a UTC timestamp.
6. The faculty dashboard updates in real time via Socket.IO to reflect each new entry.

### *A. Anti-Proxy Measures*

Each QR token is single-use per student per session, preventing forwarding. Optionally, faculty may enable geofencing: students scanning from outside a configurable radius of the classroom GPS coordinates are flagged for review rather than automatically accepted. Token payload is HMAC-SHA256 signed to prevent tampering.

### *B. Data Preprocessing & Evaluation*

Attendance records are aggregated in MongoDB and exposed via analytics API endpoints. The frontend renders attendance percentages, weekly trend charts using Chart.js, heatmaps by course and student, and automated alerts for students whose attendance falls below a configurable threshold. System performance was evaluated by measuring API response time under simulated concurrent load using Apache JMeter.

## V RESULTS & ANALYSIS

### *A. System Performance*

| Metric | Manual | QR System | Improvement | Unit |
|---|---|---|---|---|
| Accuracy | 94.7% | 99.2% | +4.5% | absolute |
| Time / Student | ~3 sec | <1 sec | ~3x faster | seconds |
| Session Setup | 3–5 min | ~8 sec | >20x faster | seconds |
| API Response (200 concurrent) | N/A | 142ms avg | — | milliseconds |
| Failed Transactions | N/A | 0 | — | count |

### *B. Analytics Utilization*

87% of faculty respondents found the analytics dashboard useful for identifying at-risk students, and 78% indicated they acted on automated absentee alerts at least once during the pilot period. The dashboard rendered course-level attendance heatmaps, weekly trend lines, and individual student attendance summaries in under 2 seconds. C. Comparison with Related Work Table 3 compares the proposed system with representative prior work in automated attendance

### *C. Comparison with Related Work*

Table 3 compares the proposed system with representative prior work in automated attendance.

**Table 3 Comparison with Related Attendance System**

| System | Technology | Hardware Required | Accuracy | Analytics |
|---|---|---|---|---|
| Nath et al. [4] | QR Code | None | ~97% | No |
| RFID System [2] | RFID | Reader | ~98% | Partial |
| Biometric [3] | Fingerprint | Scanner | >99% | Partial |
| Proposed System | QR + MERN | None | 99.2% | Yes (Real-time) |

The proposed system achieves accuracy comparable to hardware-based biometric solutions while requiring no specialized equipment, making it significantly more cost-effective and easier to deploy at scale.

## VI DISCUSSION

### *A. Strengths*

The system demonstrates several practical strengths. First, the absence of dedicated hardware dramatically reduces deployment cost compared to RFID or biometric systems. Second, the MERN stack's JavaScript-only architecture simplifies maintenance and onboarding for developers. Third, the real-time analytics dashboard bridges a gap found in most existing QR-based solutions, enabling data-driven interventions. Fourth, the modular architecture allows individual components (e.g., the QR generation module or the analytics engine) to be upgraded independently.

### *B. Limitations*

Limitations include dependency on student smartphone availability and a stable network connection. Students without smartphones or internet access cannot use the QR scanning interface. Additionally, while geofencing mitigates location-based proxy, determined adversaries could potentially spoof GPS coordinates. The current pilot was limited to four courses; large-scale institutional deployment may surface additional scalability challenges.

### *C. False Check-in Analysis*

Of the 2,280 check-in attempts during the pilot, 18 (0.8%) were flagged as anomalous: 11 due to expired QR tokens (late arrivals attempting to scan after the 5-minute window) and 7 due to geofencing violations. No confirmed proxy attendance events were detected, though the sample size is insufficient to draw strong conclusions about anti-proxy effectiveness at scale.

## VII CONCLUSION AND FUTURE WORK

This paper presented an Automated Attendance and Analytical System that replaces error-prone manual processes with a QR code-driven, real-time web application built on the MERN stack. Pilot results confirm measurable improvements in attendance recording accuracy (99.2%), session setup time (>20x faster), and faculty engagement with analytics data. The system is deployable without specialized hardware, making it accessible to institutions with limited infrastructure budgets. Future research directions include: (i) optional facial recognition as a secondary verification layer using TensorFlow.js for in-browser inference; (ii) React Native mobile wrappers for offline-capable scanning; (iii) integration with institutional Learning Management Systems via LTI 1.3 standards; (iv) machine learning models to predict chronic absenteeism and trigger early-intervention workflows; and (v) large-scale adversarial testing of the anti-proxy mechanisms under realistic conditions.

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