A QR Code Attendance And Management System

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Abstract - This paper details the design and implementation of the QR Attendance System, a contemporary, web-based solution intended to modernize and streamline student attendance management. The system is engineered around a mobile-first, dark-mode user interface (UI) developed using React.js and TailwindCSS, ensuring optimal usability and speed via device camera scanning (html5-qrcode). The back-end, powered by Flask/Python, processes attendance in realtime, applying a key feature: configurable, time-based logic to categorize status as On Time, Late, or Very Late. Attendance records are stored in a simple, portable CSV format for easy data manipulation and reporting. This architecture prioritizes cost-effectiveness, high performance, and institutional policy adherence, presenting an efficient alternative to traditional and more complex biometric attendance methods. its scalability and performance optimization, the system prioritizes cost-effectiveness, security, and maintainability by relying on open-source technologies and lightweight architecture. This approach significantly reduces infrastructure complexity while maintaining high accuracy and reliability in data processing. Comparative analysis with traditional biometric, RFID, and manual attendance methods highlights the proposed system's superiority in terms of deployment speed, adaptability, and user engagement.

Furthermore, the system supports institutional customization, enabling administrators to configure academic schedules, attendance thresholds, and reporting periods. Future enhancements may include cloud-based data storage, machine learning-driven analytics for attendance trend prediction, and integration with Learning Management Systems (LMS) for automated grading and participation tracking.

Overall, the QR Attendance System demonstrates how modern web and mobile technologies can be harnessed to deliver a flexible, efficient, and sustainable attendance management solution that aligns with the ongoing digital transformation in the education sector.

INTRODUCTION

The maintenance of accurate and efficient student attendance records is a foundational necessity in higher education, linking directly to compliance, engagement, and academic performance. The prevalent manual attendance methods—relying on paper registers and roll calls—are critically inefficient. They are resourceintensive, consume valuable class time, and are highly prone to human error, data inaccuracies, and fraudulent proxy attendance. Furthermore, their inherent lack of real-time data processing significantly delays administrative intervention for students with attendance issues. While sophisticated automated alternatives exist, such as biometric (fingerprint, facial recognition) and RFID systems, their widespread adoption is hampered by the high cost of specialized hardware and persistent student privacy concerns. This paper introduces the QR Attendance System, a modern, web-based solution designed to resolve these persistent challenges. By integrating ubiquitous mobile technology with a powerful, purpose-built architecture, the system offers a cost-effective and high-speed alternative. The core technological solution merges the accessibility of QR codes with a highly efficient mobilefirst, full-stack environment (React.js and Flask/Python). The key contributions of this research are focused on providing a practical, policy-compliant attendance model:

Efficiency and Accessibility: We demonstrate a highspeed, contactless attendance system that leverages the student's existing device camera, significantly reducing administrative time compared to traditional methods.

Customizable Punctuality Logic: The system implements a robust, server-side algorithm that moves beyond simple Present/Absent marking by enforcing institutional policy through granular, time-based classification (On Time, Late, Very Late).

Architectural Robustness: We validate the agility and performance of the lightweight React/Flask architecture combined with portable CSV data persistence for rapid deployment and simple data management

LITERATURE RIVIEW

In recent years, the automation of attendance recording has become an important aspect of academic and organizational management systems. Traditional attendance methods—such as manual sign-ins, paper registers, or verbal roll calls—are time-consuming, prone to human error, and difficult to maintain for large groups. To overcome these challenges, researchers have explored various technological approaches, including biometric systems, RFID-based systems, and QR code–based attendance systems.

According to several studies, biometric attendance systems (such as fingerprint or facial recognition) provide accurate identification of individuals but require expensive hardware and raise privacy concerns regarding the storage of biometric data. RFID systems offer contactless attendance marking but involve high installation costs and can suffer from tag duplication or reader range limitations. In contrast, QR code–based systems provide a cost-effective and userfriendly solution that can be easily implemented using existing mobile devices equipped with cameras and internet connectivity.

A QR code attendance system typically works by generating a unique, time-sensitive QR code for each session. Participants scan the code using a mobile application or web interface, and the system records their attendance along with metadata such as timestamp, location, and user ID. Studies by researchers such as Sharma et al. (2021) and Kumar & Singh (2022) emphasize that QR codes simplify attendance tracking without requiring special hardware or complex network configurations. The system’s flexibility and low implementation cost make it ideal for educational institutions, corporate environments, and training programs.

Researchers have also highlighted several advantages of QRbased systems. For instance, the work of Al-Khafaji et al. (2020) found that QR systems significantly reduce administrative workload and increase efficiency. Similarly, Prasad and Rao (2021) observed improved student engagement and real-time attendance tracking when using QR code solutions integrated with web databases. The automation of report generation and data analytics further enhances institutional productivity.

However, existing literature also identifies potential security and reliability concerns. The possibility of QR code sharing among users or duplicate scans can compromise the authenticity of attendance data. To address these challenges, studies suggest implementing mechanisms such as timelimited QR codes, encrypted tokens, and user authentication through login credentials. Integration with GPS verification or unique device identification has also been proposed to prevent fraudulent attendance marking (Nair et al., 2022).

From a usability perspective, user studies indicate that QR code–based attendance systems are generally well received by both students and faculty due to their simplicity and convenience. Systems are also compatible with existing online learning environments and can easily generate statistical attendance reports for academic analysis. Nonetheless, limitations such as network connectivity issues, camera quality, and user training requirements remain areas for further improvement.

In summary, the reviewed literature establishes that QR code–based attendance systems provide a practical, lowcost,

and efficient alternative to traditional attendance methods. They offer significant advantages in terms of accessibility, speed, and data management while maintaining minimal infrastructure requirements. Future research and development should focus on enhancing security, offline functionality, and integration with institutional databases to ensure broader adoption and reliability in diverse environments.

MATERIALS AND METHODS

The QR Code Attendance System and Management Project is designed to automate the process of recording and managing attendance through the use of Quick Response (QR) codes. The system eliminates manual entry errors, minimizes administrative workload, and provides a reliable and scalable solution for educational institutions and organizations. The architecture consists of three main components: QR Code Generation, Front-end Scanning Interface, and Back-end Application Logic.

- . *System Overview*

The QR Code Attendance System and Management Project is designed to automate attendance recording by integrating QR code technology with a centralized database and web-based interface. The system allows students to mark their attendance securely using mobile devices, while administrators can efficiently manage and retrieve attendance records through a web or desktop application. As illustrated in *Fig. 5*, the system architecture comprises four main components — Database, Web Server, Desktop Application, and Mobile Application — all interconnected to ensure smooth data exchange and verification.

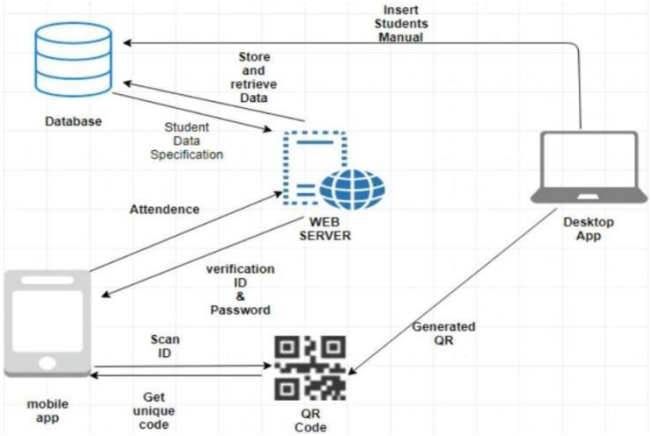

Fig. 1. System Overview

Database:
The database serves as the central data repository, storing all student information, unique QR code mappings, and attendance records. It allows data retrieval and updates through structured queries managed by the web server.

Web Server:
The web server acts as the system's core processing unit. It handles data communication between the frontend and backend, verifies user credentials (ID and password), and updates attendance logs in real time. It also generates unique QR codes corresponding to each student's ID, which are distributed for scanning.

Desktop Application:
The desktop application enables administrators or faculty members to insert and update student data manually into the system. It can also be used to generate and print QR codes for distribution to students.

QR Code Generation and Scanning:
Each student receives a unique QR code that encodes their identification number. When scanned through the mobile application, this code is sent to the web server for verification. The server validates the student's ID, records the attendance status based on time policies, and stores it in the database.

Mobile Application:
The mobile app provides students with an easy interface to scan their QR codes and receive instant confirmation of attendance. The application communicates directly with the web server, sending scanned IDs and receiving feedback messages (e.g., "On Time", "Late", or "Already Marked"). The overall workflow begins when the administrator inputs student data into the system and generates QR codes. Students then scan these codes through the mobile app, and the web server processes, verifies, and stores attendance records in the database. This seamless integration ensures accurate, real-time, and tamper-proof attendance tracking.

• *Attendance Workflow*

Preparation Stage:The administrator generates unique QR codes using the Python *qrcode* module.Each QR code is mapped to a student ID stored in *student_list.csv*.

Scanning Stage:Students open the web application on their mobile devices.The *html5-qrcode* component activates the camera to scan their QR code.

Data Transmission:The scanned student ID and current timestamp are sent to the Flask API via HTTP POST request.

Logic and Validation:The backend compares the timestamp with the defined institutional time (8:00 AM).Attendance status is determined as:

On Time: ≤ 8:00 AM

Late: 8:01 AM – 8:15 AM

Very Late: > 8:15 AM

Duplicate entries are checked to avoid multiple attendance for the same day.

Data Logging: Attendance records (Student ID, Timestamp, and Status) are appended to *attendance_logs.csv*.

Real-time Feedback: The backend returns an immediate response to frontend, showing the student's attendance status.

- Software Requirement

The software requirements for the system include React.js for building a fast and responsive front-end interface, and TailwindCSS for developing a mobile-friendly, clean user interface. The html5-qrcode library is used for enabling realtime camera access and QR code decoding directly from the browser. On the backend, the system utilizes Flask, a lightweight Python web framework, to handle API requests and execute attendance logic. The Python qrcode module is used to generate static, unique QR codes for each student. Data persistence is maintained through flat CSV files such as *student_list.csv* and *attendance_logs.csv*, which store student information and attendance records respectively. Additional development tools used include Visual Studio Code or PyCharm for coding, Node.js and npm for managing dependencies, and Postman for API testing. The system can be operated on Windows, macOS, or Linux, requiring a modern browser such as Chrome or Edge for the front-end interface.

- *Hardware Requirement*

The system requires a computer with at least an Intel Core i3 processor or an equivalent AMD processor, while an Intel Core i5 or higher is recommended for faster processing and smoother performance. A minimum of 4 GB of RAM is required for basic operation, though 8 GB or more is recommended for handling multiple users and simultaneous tasks efficiently. The project requires at least 500 MB of free storage space for storing source code, QR code images, and attendance logs, while 2 GB or more is ideal for long-term data storage and backups.

A functional camera—is essential for scanning QR codes accurately. The camera should support a minimum resolution of 720p to ensure reliable QR detection. The system interface can be viewed on any standard display with a minimum resolution of 1366 × 768 pixels, though a Full HD (1920 × 1080) screen is recommended for better visibility and user experience.

SYSTEM DESIGN

- *Data Flow Diagram*

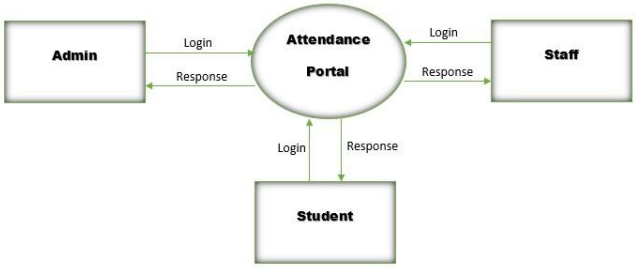

Fig.2. DFD Level:0

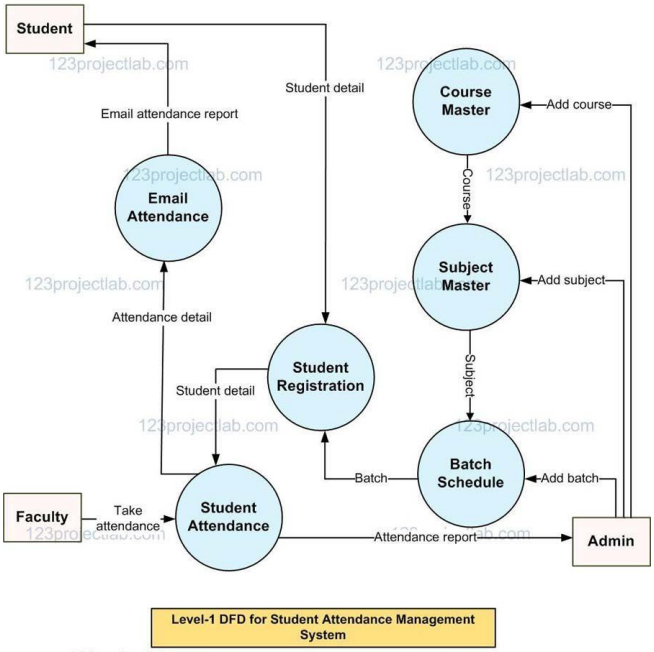

Fig.3. DFD Level:1

- *UML Diagram*

Below use case diagram illustrates a Student Attendance Management System where two primary users — the Admin and the Student — interact with various system functions. The Admin has complete control over the system and manages all major operations. They can create and update student profiles containing personal and academic details, as well as parents' profiles for communication purposes. The Admin also maintains the attendance records, configures SMS settings to send alerts or notifications to parents, and uses the QR generator to create unique QR codes for each student, which simplify attendance tracking. Additionally, the Admin can use the QR code scanner to mark attendance, perform database backups to secure data, and generate reports for monitoring attendance and performance. Meanwhile, the Student interacts with the system in a limited way — they can view their profile, check their attendance record, and use the QR code scanner to mark attendance. Overall, the diagram demonstrates how the Admin oversees and controls all system functions while the Student mainly participates in attendance-related tasks, ensuring efficient, accurate, and paperless management of student attendance. Student plays a participatory role. They can access their Student Profile to verify or update personal details, check their Attendance Record to stay informed about their presence and absences, and use the QR Code Scanner to mark attendance when entering the classroom or campus. This interaction makes the process transparent and efficient for both students and administrators. In essence, the diagram illustrates a structured system that minimizes manual work, enhances accuracy through automation, and promotes

smooth communication between students, parents, and school management. It emphasizes how technology, through QR codes and SMS notifications, simplifies attendance tracking while ensuring data security and accessibility for all users.

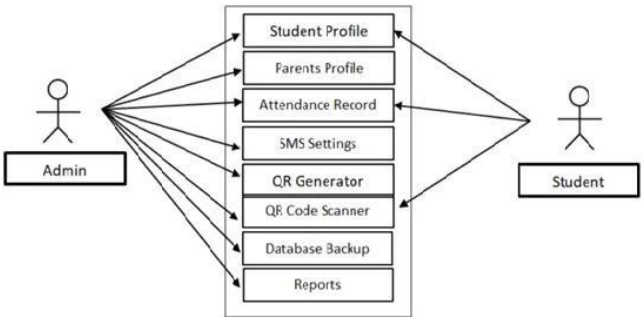

Fig.4. Use Case Diagram

PROJECT ANALYSIS

- *PROJECT ESTIMATE*

The QR Code Attendance System and Management Project is a cost-effective solution developed primarily using open-source and freely available technologies, making it financially feasible for educational institutions and small organizations. The software tools used in the project—such as React.js, Flask (Python), TailwindCSS, and html5qrcode—are all open-source frameworks that do not require any licensing fees. Additional tools like Visual Studio Code, Postman, and Git are also free, further reducing the development cost. The hardware requirements are minimal, as the system can be implemented using existing institutional resources such as computers, laptops, or smartphones equipped with cameras for QR code scanning. A standard machine with at least an Intel Core i3 processor, 4 GB RAM, and a stable internet connection is sufficient for development and deployment.

The project can be hosted locally on a Flask development server or deployed on free cloud platforms such as Render or Heroku, eliminating hosting expenses during the testing or prototype phase. The human resource cost is also low, as a small team of two to three developers with basic knowledge of web development and Python programming can complete the entire project within four to six weeks, including design, implementation, and testing. Maintenance costs are negligible, limited mainly to occasional data backups and optional upgrades if the system is expanded to use a database like MySQL or PostgreSQL in the future.

Overall, the estimated total cost of the QR Code Attendance System and Management Project is minimal, as it leverages open-source software, low-cost hardware, and readily available infrastructure. This makes the system economically feasible, efficient, and highly suitable for institutions seeking an affordable yet modern solution for automating attendance management.

- RISK MANAGEMENT
- Identification of Risks

Risks associated with a training and placement management system include: third-party risks from external services or vulnerable libraries; integration risks like API vulnerabilities and data mismatches; regulatory noncompliance; poor user experience due to confusing user interfaces or inconsistent behaviour; and data security threats like unauthorised access, data breaches, and insecure storage.

- *Evaluation of Risk*

Finding threats such as data breaches, system outages, integration challenges, poor user experiences, noncompliance with regulations, vendor dependence, and data integrity issues are all part of risk analysis. Along with constant risk monitoring and updating, each risk should be assessed for likelihood and impact, ranked appropriately, and addressed with tactics like improved user training, frequent backups, and more robust security.

- *Overview of Risk Mitigation, Monitoring, and Management*

Regularly detecting and evaluating risks, ranking them according to their significance, and implementing mitigation strategies including security controls, frequent updates, training, and backup systems are all part of risk management.

Monitoring entails identifying new risks, performance problems, and security mishaps. Through stakeholder communication, risk plan updates, and experience-based learning, management guarantees ongoing progress.

- *PROJECT SCHEDULE • Project Workload*

The Training and Placement Management System project timeline is divided into multiple stages. Determining the scope, goals, deliverables, stakeholders, timeline, and communication strategy are the main goals of the two-week project planning phase. Needs The three-week gathering process entails gathering both functional and non-functional requirements, interviewing users, developing use cases, and locating data sources. Database schema, UI/UX design, security features, and system architecture are all covered in the four-week System Design course. Development of components, testing, and performance optimization are all part of the 10-week implementation phase. User Acceptance Validation and bug fixes are the main goals of the two-week testing period. The last phase, Deployment and Maintenance, lasts for four weeks and includes system deployment, user training, support setup, and a postimplementation review.

- *Task Network*

The project's task network flows logically: Project Planning establishes the general framework, and Requirements Gathering collects specific demands. The next step is system design, which focuses on creating interfaces, databases, and architecture. Through coding, testing, and security measures, implementation gives the designs life. User Acceptance Testing is carried out following development to make sure the system lives up to user expectations. Finally, Deployment and Maintenance entails system launch, user training, system maintenance, and project success evaluation.

D. TEAM ORGANIZATION

- *Structure of the Team*

There are important jobs in the Training and Placement Management System team. The team leader oversees all planning, communication, and coordination while managing stakeholder interactions and making sure deadlines are fulfilled. The backend developer creates the server-side logic, manages APIs and database integration, and keeps security in check. Using HTML, CSS, and JavaScript, the frontend developer produces the user interface and experience, guaranteeing a responsive and intuitive design. In addition to managing database architecture, optimization, and security, the Database Administrator (DBA) collaborates closely with the backend developer to ensure effective data processing.

- *Reporting and Communication in Management*

Effective communication and reporting are critical to the success of any project. Reports can be delivered via written reports, presentations, or both, and should be scheduled weekly, biweekly, or monthly, depending on the level of complexity. System availability and storage reduction are two examples of Key Performance Indicators (KPIs) that are used to track progress. It is necessary to keep important stakeholders informed on a frequent basis using project management software, video conferencing, or email. A suitable change management procedure must be followed for any scope, time, or budget changes, and risks and difficulties should be communicated as soon as possible with mitigation strategies.

- *PROJECT IMPLEMENTATION*

- *Project Model Overview*

The implementation of the QR Code Attendance System and Management Project follows a modular and phased development model to ensure smooth integration of all components and efficient system functionality. The project is implemented using the Waterfall Model, which involves sequential stages of development—requirement analysis, system design, implementation, testing, and deployment. This model ensures that each stage is completed before moving on to the next, maintaining clarity and structure throughout the development process.

In the initial requirement analysis phase, the system objectives were defined, focusing on automating the attendance process using QR code technology. The system design phase involved creating a blueprint of the system architecture, including frontend, backend, and data flow structures. The implementation phase focused on developing the application components — the frontend using React.js and TailwindCSS for a responsive user interface, and the backend using Flask (Python) to handle business logic, data validation, and attendance management. The html5-qrcode library was integrated to allow real-time camera access and QR code decoding, enabling students to scan their unique codes directly through their device cameras. During the testing phase, the system was evaluated for accuracy, speed, and reliability. The application was tested using multiple student QR codes to ensure that duplicate entries were prevented and that the correct attendance status (On Time, Late, or Very Late) was recorded according to institutional policies. The data storage layer, based on simple CSV files, was tested for proper logging and retrieval of attendance records. Once the system passed functional and performance testing, it was deployed on a local server environment for real-time usage and validation.

The modular nature of the project design allows for easy scalability and future enhancements. Features such as database integration, admin dashboards, and report generation can be added without altering the core functionality. Overall, the project implementation ensures a reliable, cost-effective, and user-friendly attendance management system that improves institutional efficiency and minimizes manual errors.

- RESULT

1 The developed QR Code Attendance System and Management Project successfully achieved its main objective of automating the attendance process in an accurate, efficient, and secure manner. By integrating QR code technology with a web-based interface, the system eliminated manual paperwork and minimized human error commonly encountered in traditional attendance systems.

2 Each student was assigned a unique, static QR code generated using the Python *qrcode* module. These codes were systematically linked to student records in *student_list.csv*, ensuring that every QR code accurately represented a single individual. This eliminated the possibility of duplication and maintained the integrity of attendance records.

3 The frontend scanning module, developed using React.js and styled with TailwindCSS, provided a responsive

and user-friendly interface. Through the integration of the html5-qrcode library, the system enabled real-time camera access, allowing students to scan their QR codes directly using their mobile devices or webcams. The scanning process was smooth, fast, and compatible with multiple devices and browsers.

4 On successful scanning, the decoded student ID was transmitted to the Flask backend server along with a system-generated timestamp. The backend system, built using the Python-based Flask framework, applied institutional attendance policies to determine the student's attendance status.

5 The attendance classification logic worked accurately according to predefined rules:

- *On Time*: Student marked attendance exactly at 8:00 AM.
- *Late*: Attendance marked between 8:01 AM and 8:15 AM.
- *Very Late*: Attendance marked after 8:15 AM. This logic ensured consistency and fairness in the evaluation of punctuality while maintaining transparency in the process.

6 The Flask API also implemented a duplicate entry check, preventing multiple attendance submissions for the same student on the same day. This feature significantly improved the accuracy and reliability of stored data, ensuring that each student's attendance was recorded only once per session.

7 All processed data, including the student ID, timestamp, and attendance status, were stored in a CSV file (attendance_logs.csv). The use of CSV ensured simplicity, portability, and easy access for administrators. It allowed direct viewing and manipulation through spreadsheet software without requiring database expertise, making it ideal for small to medium-sized institutions.

8 After successful data logging, the system provided instant feedback to students through the frontend interface. The feedback displayed the student's name and attendance status ("On Time," "Late," "Very Late," or "Already Marked") immediately after scanning, enhancing user experience and providing confirmation in real-time.

CONCLUSION

The Student Attendance Management System use case diagram provides a comprehensive view of how digital automation can simplify and strengthen attendance management in educational institutions. It clearly defines the interaction between the Admin and the Student, outlining their specific responsibilities and system privileges. The Admin acts as the controller of the entire system, managing student and parent information, maintaining attendance records, configuring SMS alerts for communication, generating and scanning QR codes for attendance, securing data through database backups, and producing detailed reports for monitoring performance and discipline. The Student, on the other hand, uses the system to view personal details, check attendance status, and mark attendance efficiently through QR scanning.

This diagram emphasizes how technology streamlines daily administrative tasks, replacing traditional paper-based systems with a faster, more reliable, and transparent digital process. It ensures data accuracy, minimizes human errors, improves communication between the institution and parents, and provides easy access to attendance information. Overall, the system not only enhances efficiency and accountability but also contributes to building a more organized, secure, and technology-driven learning environment.

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