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QR Based Smart Attendance and Reporting System

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Abstract

The evolution of technology has significantly transformed traditional attendance monitoring systems into automated, efficient, and paperless solutions. Conventional attendance methods, such as manual roll calls, fingerprint scanners, or face detection, often require additional infrastructure and are time- consuming. To address these limitations, several researchers have proposed QR code–based attendance systems that utilize smartphones and servers to record and manage attendance efficiently. These systems generate unique QR codes containing essential details like course, subject, date, and session information, which students scan using their mobile devices to mark their presence. The attendance data is then securely uploaded to a centralized server, where it can be verified and stored for generating reports in Excel or PDF format. Some systems also integrate facial verification features to ensure authenticity and prevent false registrations. The reviewed studies collectively demonstrate that the QR-based attendance management approach offers an effective, eco-friendly, and automated alternative to manual methods, minimizing human effort, improving data accuracy, and enhancing institutional transparency.

Introduction

Attendance plays a vital role in evaluating student performance and maintaining discipline within educational institutions. Traditionally, attendance has been marked manually by calling roll numbers or signatures, which is time-consuming and prone to human errors and proxy issues. As class sizes increase, this manual process becomes inefficient and less reliable, creating challenges for both instructors and administrative staff. To overcome these limitations, various Automatic Attendance Systems (AAS) have been developed, incorporating biometric verification, RFID tags, and barcode scanning methods. However, these systems often require specialized infrastructure such as scanners and proprietary servers, which can be expensive and difficult to maintain. Recent studies highlight the growing use of smartphones and QR code technology as a more affordable and flexible alternative for attendance management. With the rapid advancement of mobile technology and widespread availability of internet connectivity, smartphones are now powerful enough to handle scanning, verification, and data synchronization with cloud servers. Systems utilizing QR codes enable teachers to quickly record attendance by generating unique codes containing student or course information, which students scan using their mobile devices. The scanned data is then transmitted to a centralized database for verification and report generation. Furthermore, the integration of feature such as automated email notifications enhances data accuracy and authenticity, reducing the likelihood of false attendance entries. Overall, smartphone-based QR attendance systems

represent an efficient, paperless, and scalable approach to attendance monitoring that aligns with modern educational technology trends.

Modern attendance systems improve transparency and accountability by allowing students, teachers, and administrators to easily access digital records. This reduces errors, confusion, and helps in quick report generation and better decision-making. Web-based systems provide flexibility, as they can be accessed anytime and anywhere using internet-enabled devices. Features like real-time updates, secure login, and centralized databases ensure accurate and up-to-date attendance information.

These systems can also integrate with other academic services, such as performance tracking and notifications. Overall, QR-based attendance systems offer a cost-effective, scalable, and efficient solution for modern educational institutions.

Literature Review

Several studies have been conducted to automate attendance systems using modern technologies such as QR codes, NFC, and facial recognition.

Bacuna et al. (2022) developed a QR-based attendance system (eSAM) that allows students to scan QR codes and send attendance data to a server. The system also includes features such as facial image capture and report generation. However, the system mainly focuses on attendance recording and reporting, with limited emphasis on real-time cloud synchronization and scalability.

Shah (2020) proposed a QR-based attendance system using mobile devices and network-based identification such as MAC addresses to prevent proxy attendance. While the system reduces dependency on hardware, it relies heavily on network configurations and device-specific parameters, which may not always be reliable in dynamic classroom environments.

A QR Code Based Smart Attendance System (2017) introduced a dual-application approach for generating and recording attendance. The system stores data in a local database such as SQLite and generates reports. However, it lacks real-time synchronization and cloud-based accessibility, limiting its usability in modern distributed systems.

Bharat et al. (2022) proposed a QR-based system integrated with GPS tracking to enhance security. Although this approach reduces proxy attendance, it depends on location tracking, which may not provide accurate results in indoor environments and can affect system reliability.

Pawar et al. (2018) introduced an NFC-based attendance system where students use NFC cards for marking attendance. While this system improves accuracy, it requires additional hardware such as NFC-enabled devices and cards, increasing cost and maintenance overhead.

Recent work using facial recognition (2023) provides automated attendance using machine learning techniques. Although highly advanced, such systems require high computational power, good image quality, and raise concerns related to privacy and implementation complexity.

Problem Definition and Proposed System

Problem Definition

In many educational institutions, attendance is still managed using traditional paper-based methods or basic digital systems. These approaches are time-consuming, prone to human errors, and inefficient for large classrooms. Manual attendance marking often leads to issues such as proxy attendance, data mismanagement, and lack of transparency.

Existing automated systems such as biometric, RFID, or NFC-based solutions require additional hardware, which increases cost and maintenance complexity. Similarly, some QR-based systems lack real-time synchronization and scalability, while advanced systems like facial recognition are complex and raise privacy concerns.

Moreover, many existing systems do not provide real-time access to attendance data, making it difficult for students, teachers, and administrators to monitor attendance effectively. Therefore, there is a need for a simple, secure, cost-effective, and real-time attendance management system.

Proposed System

The proposed system is a web-based smart attendance management system designed to overcome the limitations of traditional and existing attendance systems. It is developed using technologies such as Spring Boot, Thymeleaf, and Firebase Realtime Database to provide a scalable, real-time, and efficient platform for attendance management.The system provides role-based access with separate login panels for Admin, Teacher, and Student. Each user has access only to the functionalities relevant to their role, which improves usability and system organization.

A key feature of the system is the QR-based attendance mechanism. Teachers can generate a dynamic QR code for each lecture, which contains a unique encrypted token and is valid only for a limited time. Students can scan the QR code using their mobile devices to mark attendance instantly. This mechanism

significantly reduces the chances of proxy or fake attendance.As a backup option, the system also allows students to mark attendance using a subject-specific code, ensuring flexibility in case QR scanning is not possible.

All data, including student details, teacher information, subjects, and attendance records, is stored in Firebase Realtime Database. This enables real-time data synchronization, allowing instant updates across all users without requiring manual refresh. It also improves accessibility and scalability of the system.Security is ensured through authentication and authorization mechanisms. User accounts are protected, and sensitive data is securely managed using Firebase security rules and encrypted communication. This ensures that only authorized users can access or modify attendance data.

Overall, the proposed system provides a smart, secure, and real-time solution for attendance management. It reduces manual effort, improves accuracy, enhances transparency, and supports modern cloud-based data handling, making it suitable for next-generation educational institutions.

System Architecture and Design

1. System Architecture

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The proposed Smart Attendance System is designed using a layered architecture consisting of the Presentation Layer (web application for teachers and administrators, and mobile interface for students), the Application Layer (Spring Boot backend handling business logic), and the Data Layer (Firebase Realtime Database for data storage). The web application communicates with the backend through secure HTTP requests, ensuring proper data flow and system control. Role-based authentication is implemented to provide controlled access for Admin, Teacher, and Student users.

Figure 1 illustrates the overall system architecture, showing the interaction between users (Teacher and Students), system components (Web App and Mobile devices), QR code mechanism, and the cloud database. The teacher generates a QR code using the web application, which is scanned by students through mobile devices, and the attendance data is transmitted via the internet to the database. The system then processes and stores records in Firebase and generates attendance reports accessible to authorized users. This architecture ensures scalability, real-time data synchronization, and efficient attendance management.

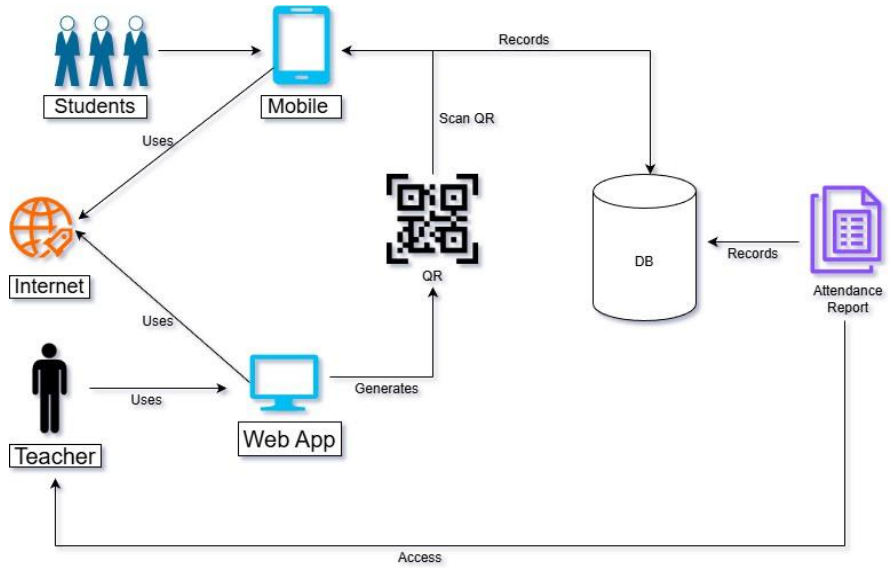


Fig. 1: System Architecture

2. Technology Stack

The system employs Thymeleaf with HTML, CSS, and Bootstrap to build a responsive and user-friendly frontend interface that works seamlessly across desktop and mobile devices. The backend is developed using Spring Boot, which provides efficient request handling, modular architecture, and easy integration with other components.

For data storage, the system uses Firebase Realtime Database, enabling real-time data synchronization and cloud-based access without the need for complex SQL queries. This ensures fast data retrieval and scalability. Spring Security is implemented for authentication and authorization, providing secure login functionality and role-based access control for Admin, Teacher, and Student users. Passwords

are stored in encrypted form to enhance security. Additionally, the system uses RESTful APIs for communication between frontend and backend, and supports report generation features for managing attendance data efficiently.

Design And Implementations

1. Data Flow Diagram – Level 0

The Level 0 DFD (Context Diagram) presented in Figure 2 provides a top-level view of the Meal Management System, depicting the system as a single process interacting with five external entities: Hospital Staff, Mess Provider, Hospital Management, Delivery Personnel, and Admin. Hospital Staff inputs patient meal orders and dietary information into the system and receives order confirmations and records in return. Mess Providers supply menu updates and confirmations, receiving real-time order data for meal preparation. Hospital Management receives invoices, financial reports, and order summaries. Delivery Personnel receive route assignments and delivery orders, feeding back delivery status updates.

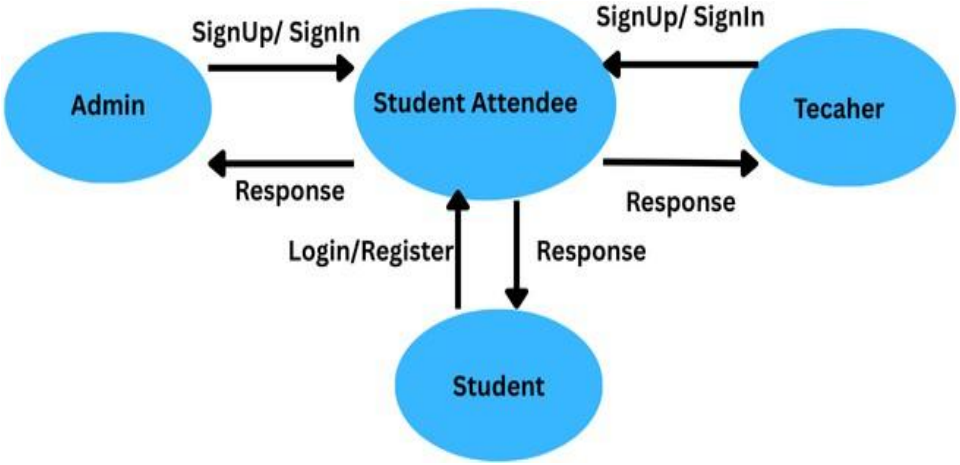


Fig. 2: DFD Level 0

2. Data Flow Diagram – Level 1

The Level 1 Data Flow Diagram provides a detailed representation of the Smart Attendance System by dividing it into three main modules: Admin, Teacher, and Student.

The admin module manages system setup by adding teachers and creating classes. The Teacher module handles academic operations such as adding subjects and generating QR codes for attendance. The student module interacts with the system by scanning the QR code to mark attendance.

All these processes are connected through the central system, ensuring smooth data flow and proper execution of attendance operations.

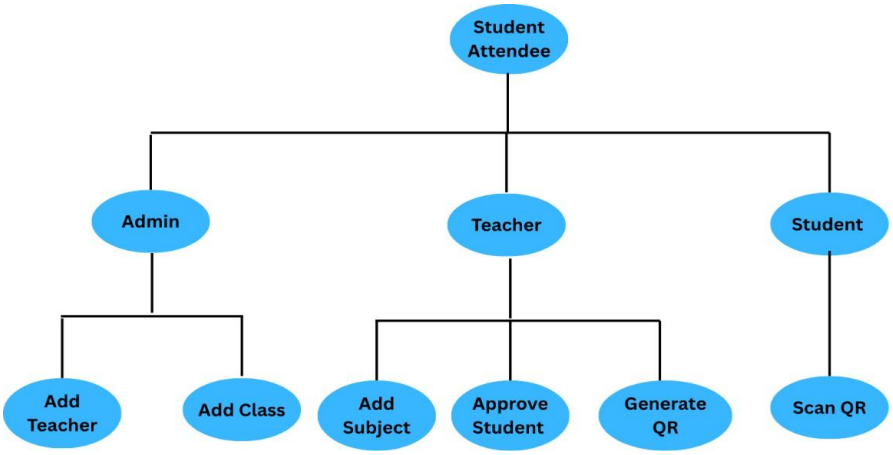


Fig. 3: DFD Level 1

3. Data Flow Diagram – Level 2

The Level 2 Data Flow Diagram provides a detailed breakdown of internal processes of the Smart Attendance System, including data storage and flow between different modules such as Admin, Teacher, and Student.

The Admin module is responsible for managing user-related data. The admin can add teachers by entering details such as username, name, and password, and also create classes by providing class name and class ID. This data is stored in the User Database for further use.The Teacher module manages academic activities. The teacher can add subjects by entering subject name and subject ID, which are stored in the Subject Database. The teacher also generates QR codes for attendance and can send notifications such as emails. Additionally, the teacher can view attendance records, which are retrieved from the Attendance Database.

The Student module interacts with the system by scanning the QR code to mark attendance. Once scanned, the attendance is recorded and stored in the Attendance Database.

All collected data is processed and used to generate reports and analysis, which help administrators and teachers monitor attendance effectively.

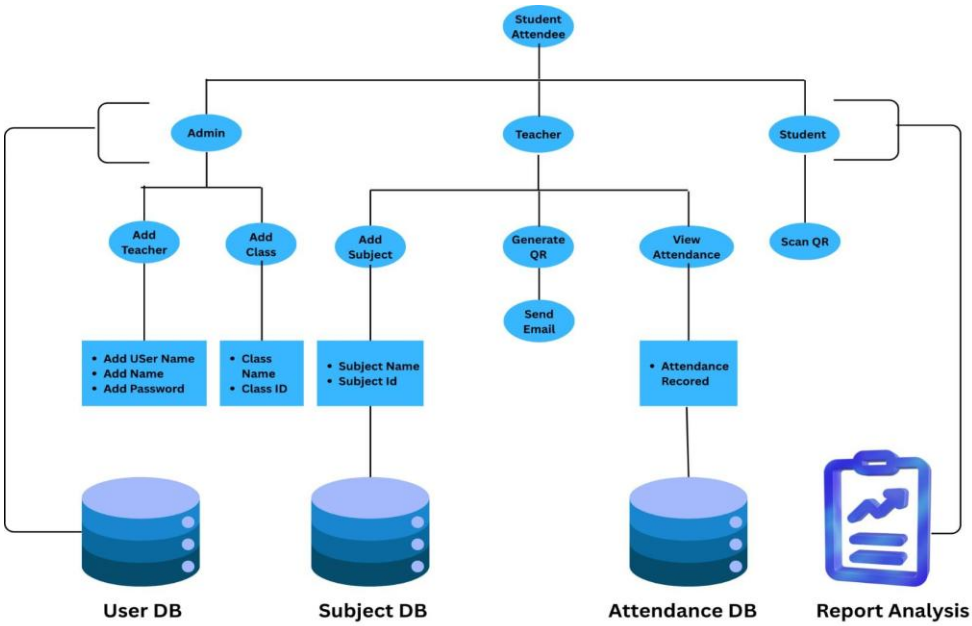
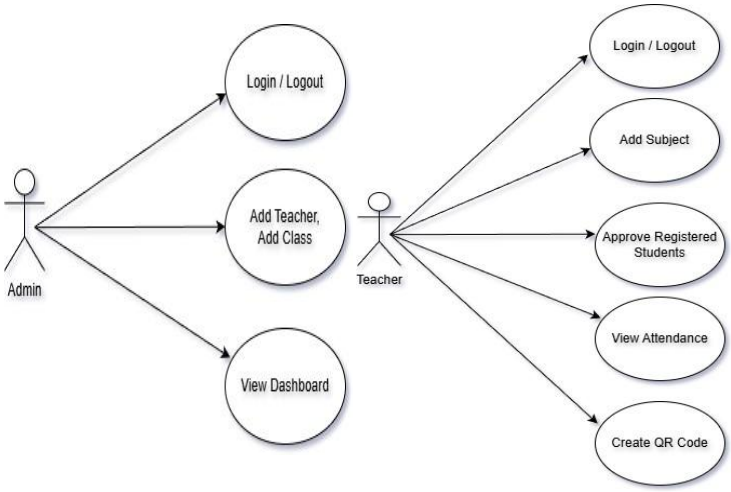


Fig. 4: DFD Level 2

4. Use Case Diagram

Figure 4 presents the Use Case Diagram for the Tiffin Management System, illustrating the functional interactions between the two primary actors—Hospital Staff and Mess Provider—and the system use cases. Hospital Staff can place orders, view order history, manage patient records, and generate daily reports. Mess Providers can view received orders, approve and update delivery status, manage canteen operations, and download PDF order summaries. Both actors authenticate through the role-based login interface, and all use cases are encapsulated within the system boundary representing the TMS web application.



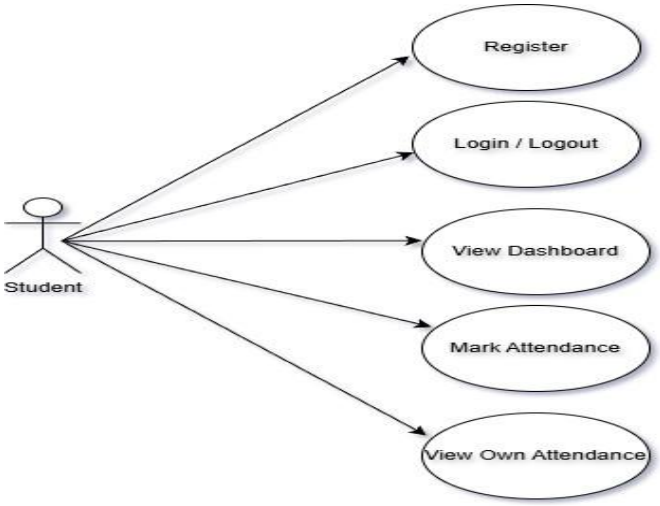


Fig. 5: Use Case Diagram

Results And Discussion

The proposed Smart Attendance System was successfully developed and tested using Spring Boot, Thymeleaf, and Firebase Realtime Database. The system was evaluated based on functionality, usability, and performance in a simulated classroom environment.

The results show that the system effectively automates the attendance process using QR code technology. Teachers were able to generate QR codes quickly for each lecture, and students could mark their attendance instantly by scanning the code using their mobile devices. This significantly reduced the time required for attendance compared to traditional roll-call methods.

The use of time-bound QR codes with unique tokens helped in minimizing proxy attendance. The system ensured that only students present during the lecture could mark attendance within the given time limit. Additionally, the backup option of subject code entry provided flexibility in case of technical issues.

Firebase Realtime Database enabled instant data synchronization, allowing attendance records to be updated and accessed in real time. Teachers could view attendance data immediately after the session, and students could track their attendance status without delay. This improved transparency and accessibility.

The system also demonstrated good performance in handling multiple users simultaneously without significant delay. The role-based access control ensured that only authorized users could access specific features, enhancing system security.

Overall, the results indicate that the proposed system is efficient, reliable, and user-friendly. It reduces manual effort, improves accuracy, prevents fraudulent attendance, and provides real-time monitoring and reporting capabilities, making it a suitable solution for modern educational institutions.

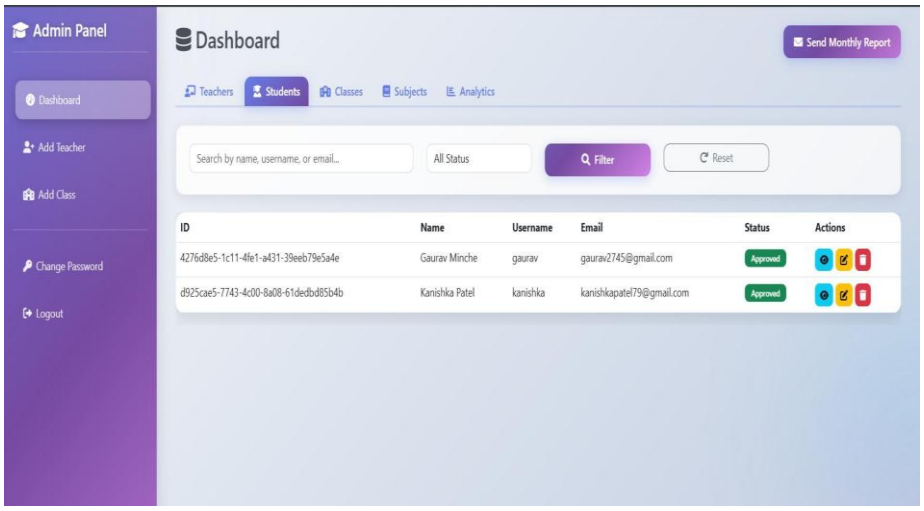


Fig. 6: Admin Dashboard

The Admin Dashboard allows efficient management of student records, including viewing details, filtering data, and performing actions like edit or delete.

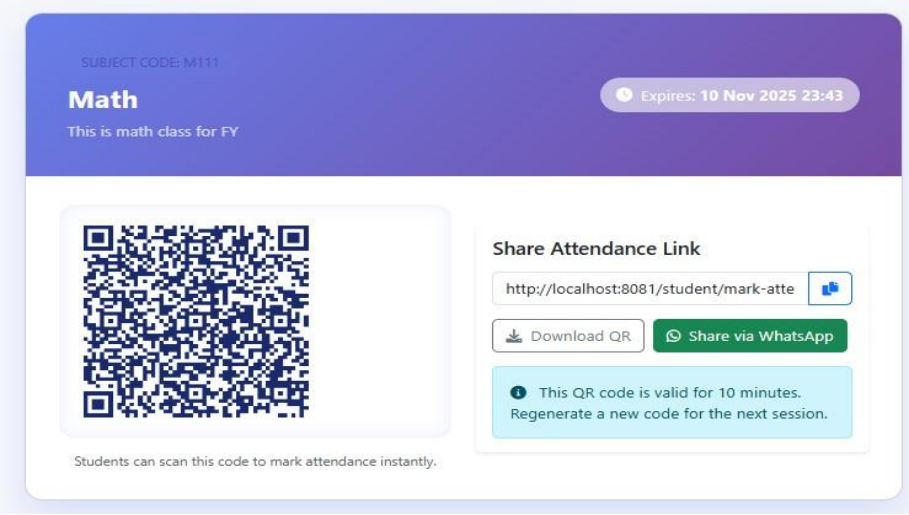


Fig. 7: QR Generation

The QR Attendance screen allows teachers to generate ancode for students to quickly mark their attendance.

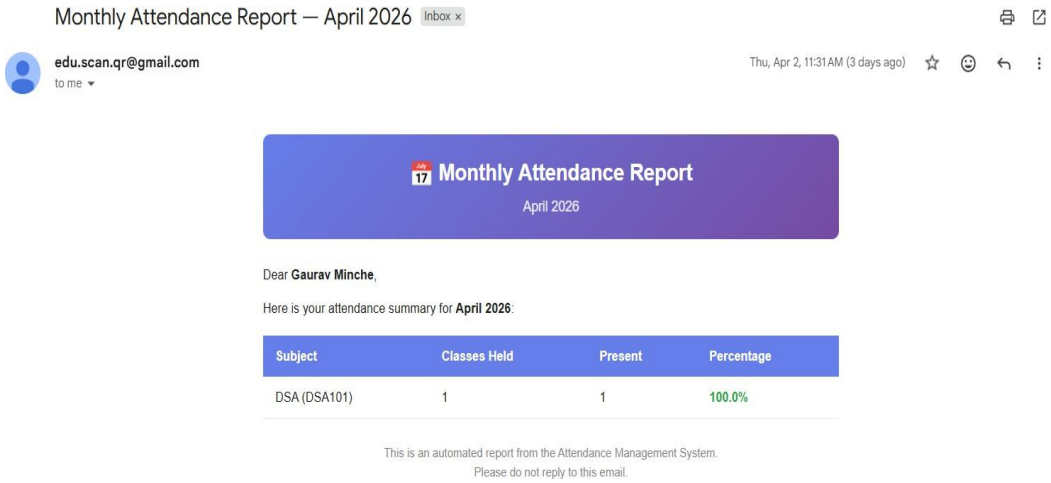


Fig. 8: Received Email

The system automatically generates and sends monthly attendance reports to students via email, providing a clear summary of their attendance performance.

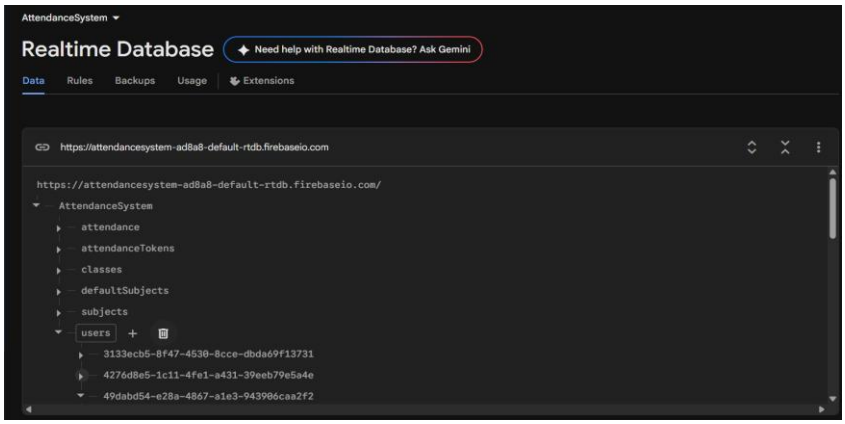


Fig. 9: Database

The system uses a real-time database to store and manage attendance data efficiently, ensuring quick updates and seamless data synchronization.

Conclusion

The QR-based Smart Attendance System presents an effective and modern solution for managing attendance in educational institutions. By replacing traditional manual methods with a QR-based approach, the system significantly reduces time consumption, minimizes human errors, and improves overall efficiency in classroom management. The integration of web technologies such as Spring Boot and Thymeleaf, along with Firebase Realtime Database, enables real-time data synchronization and secure cloud-based storage. This ensures that attendance records are instantly updated, easily accessible, and well-organized. The use of time-bound QR codes enhances security by reducing the possibility of proxy attendance, thereby increasing the reliability of the system.

The system is user-friendly and does not require any additional hardware, making it cost-effective and easy to deploy in institutions of varying sizes. Teachers can efficiently generate QR codes and monitor attendance, while students can quickly mark their presence using mobile devices. The availability of automated reports and analytics further supports better decision-making and monitoring. Additionally, the system demonstrates scalability and flexibility, as it can handle large numbers of users and can be extended with future technologies such as AI-based verification or mobile application integration. It promotes transparency by allowing students and teachers to access attendance records in real time. In conclusion, the proposed system successfully modernizes attendance management by providing a secure, efficient, and practical solution that aligns with the needs of digital education systems.

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