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SmartERP: An Intelligent Android-Based Student Management and OTP-Verified Attendance System Using Firebase Cloud Services

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Abstract: *Tracking student attendance and managing daily academic records remains a significant administrative burden in modern educational institutions. Traditional methods, such as paper-based roll calls or manual spreadsheet entries, consume valuable instructional time and are highly susceptible to proxy attendance, where students falsify records for their absent peers. To address these issues, this paper introduces SmartERP, an integrated, cloud-backed Android application designed to streamline college administration. The system replaces outdated attendance methods with a dynamic One-Time Password (OTP) verification mechanism. Faculty members generate a cryptographically secure 6-digit code via Google Firebase, which automatically expires after exactly 180 seconds. This strict time constraint mathematically minimizes the opportunity for off-campus credential sharing. Beyond attendance tracking, SmartERP acts as a centralized educational portal featuring role-based authentication, automated Excel attendance sheet exports, unit test marks management, digital note sharing, an anonymous faculty feedback system, and real-time push notifications. The application was developed using the Agile methodology and relies on a serverless Firebase backend (Realtime Database, Authentication, and Cloud Messaging). Comprehensive testing, including high-concurrency stress testing and usability audits, confirms that the system entirely eliminates proxy attendance, reduces the time taken for roll calls by over 70%, and provides significant administrative productivity gains for teachers.*

Keywords: Android Application, Firebase Realtime Database, OTP Attendance Verification, Push Notifications, Apache POI Excel Export, Student Management System

I. INTRODUCTION

The integration of mobile technology and cloud computing has dramatically reshaped how educational institutions handle their administrative operations. Among all daily academic routines, recording and verifying student attendance is one of the most repetitive and time-consuming tasks. Reliable attendance data is crucial, as it directly impacts student evaluation, exam eligibility, and overall academic performance tracking. Despite the availability of digital tools, a vast majority of colleges continue to rely on manual roll calls or paper sheets[1].

Relying on manual attendance creates several critical problems. First, it results in a substantial loss of teaching time. Research indicates that conducting a manual roll call can consume 10% to 20% of a standard 50-minute lecture, a cumulative loss that severely impacts the academic term[2]. Second, manual transcription is prone to human error, often leading to lost data or incorrect spreadsheet entries. Most critically, manual tracking is highly vulnerable to proxy attendance (or "buddy punching"), where students answer on behalf of absent friends, drastically undermining academic integrity.

To combat these vulnerabilities, researchers have developed various automated systems. Biometric scanners (fingerprint or facial recognition) offer high security[3], but they require expensive hardware in every classroom and raise hygiene

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concerns[4]. Radio-Frequency Identification (RFID) systems speed up the process but remain susceptible to proxy fraud if students simply swap their ID cards[5]. Quick Response (QR) code systems provide a low-cost mobile alternative[6], yet static QR codes can easily be photographed and sent to absent students, effectively bypassing the system's security[8].

This paper proposes *SmartERP*, a cost-effective, Bring-Your-Own-Device (BYOD) Android application designed to secure the attendance process without requiring external hardware. By utilizing Google Firebase Cloud Services, the system generates a dynamic, 6-digit verification code on the instructor's device[9]. Because this code expires in exactly three minutes, off-site students cannot reliably receive and use it in time. Furthermore, *SmartERP* integrates essential academic features—such as automated Excel reports, real-time push notifications, and grade tracking—into a unified, user-friendly platform.

II. LITERATURE REVIEW

The evolution of automated attendance systems highlights a continuous effort to balance security, cost, and user convenience. Recent literature generally categorizes these systems into hardware-reliant biometrics, visual QR scanning, location-based geofencing, and cloud-based mobile applications.

A. Biometric and Hardware-Based Systems: To definitively link attendance to an individual, many institutions turned to biometrics. Multi-level authentication systems combining fingerprint scanning with One-Time Passwords (OTPs) have been shown to virtually eliminate proxy fraud[4]. Advanced studies have also explored facial recognition paired with liveness detection (e.g., tracking eye blinks) to prevent photo spoofing[10]. Similarly, ocular feature extraction has been utilized to bypass masking interference[11]. While highly secure, these systems face practical deployment barriers. Installing fingerprint or iris scanners across a campus is financially prohibitive, and facial recognition requires significant on-device computational power that many budget student smartphones lack[3]. IoT-based RFID networks successfully speed up classroom entry[5], but as the system authenticates the physical tag rather than the student, the vulnerability of card-swapping remains largely unresolved.

B. Visual Identification and QR Codes: QR code-based systems have gained immense popularity due to their low implementation cost. Standard implementations allow students to scan a static code projected on a screen to mark their presence[6]. However, static QR codes are easily compromised via photo sharing. To counter this, developers have proposed dynamic QR codes that refresh every 60 seconds or embed device-specific IMEI data into the payload[2]. While dynamic QR systems improve security, they heavily tax the mobile device's camera and battery, and students seated far from the projector often struggle with scanning reliability.

C. Geofencing and GPS Tracking: Geofencing utilizes GPS coordinates to restrict attendance marking to a specific geographic boundary[12]. Systems like MDXApp successfully combine real-time location data with attendance codes to verify physical presence[13]. Advanced implementations use moving average algorithms and Kalman filters to smooth out GPS inaccuracies[14]. Other cross-platform applications built in Flutter have demonstrated that combining geofencing with Firebase creates a robust tracking environment for employees and students[15]. However, pure geofencing struggles significantly with Z-axis (altitude) precision. In multi-story campus buildings, standard smartphone GPS cannot reliably distinguish whether a student is on the third-floor lecture hall or the ground-floor cafeteria.

D. Cloud-Based Platforms and the OTP Approach:To bypass both hardware costs and GPS limitations, many researchers are building purely software-driven management systems using Google Firebase. Applications like "Breeze" and other Firebase-backed portals utilize NoSQL real-time databases to handle student management, timetable scheduling, and notifications efficiently[9]. Building upon this cloud-first foundation, *SmartERP* addresses the proxy attendance issue by implementing a strict, time-bound One-Time Password (OTP) model[1]. By generating a cryptographically secure code that definitively expires after 180 seconds, the system creates a tight temporal window that renders off-site credential sharing mathematically and operationally impractical[2].

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III. PROPOSED SYSTEM

The system follows a client-server model (Fig. 1). The Android app (installed on teacher and student devices) communicates with Firebase Cloud Services. We use Firebase Authentication for sign-in, Firebase Realtime Database for storing attendance, notes, and grades, and Firebase Cloud Messaging (FCM) for notifying apps of new events (e.g. "OTP generated", "new announcement"). An LLM-powered microservice (hosted on Google Cloud Functions or similar) interfaces via REST API to handle chatbot queries, retrieving knowledge from a Firebase cache.

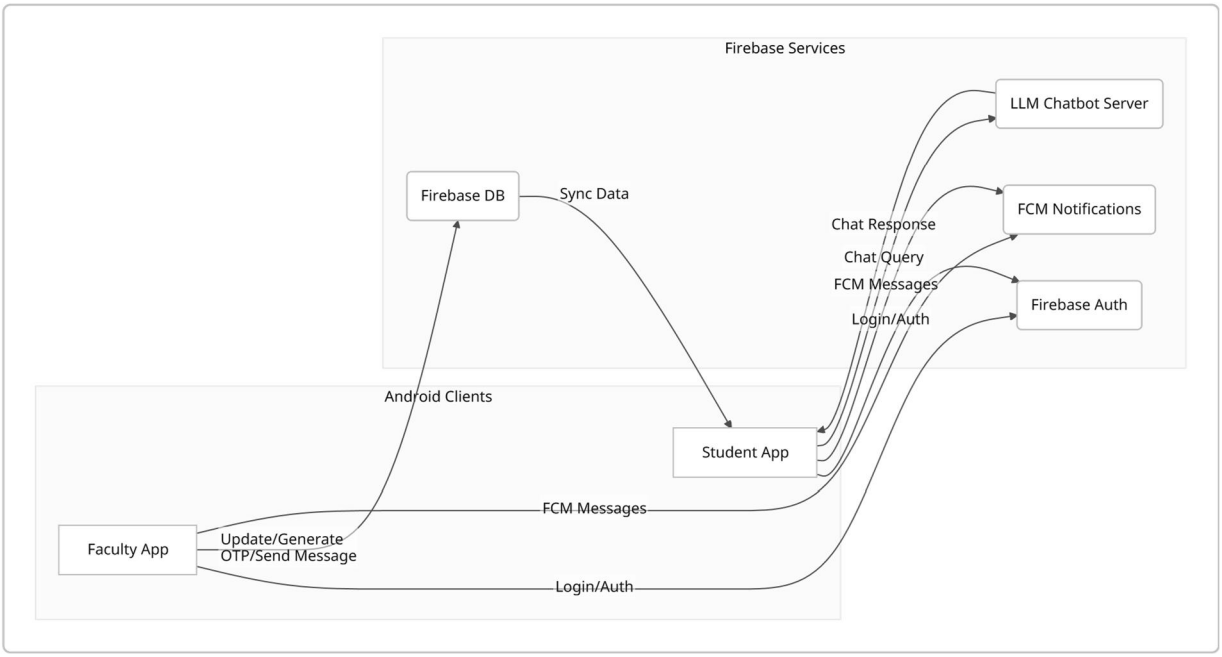

Fig. 1. SmartERP system architecture (Android clients, Firebase backend, and AI service).

OTP Attendance Workflow

The OTP attendance flow (Fig. 2) ensures security: the teacher's app generates a random code with timestamp T. Firebase writes {otp:code, time:T} to the course node. Student apps receive a push (via FCM) or poll and display the code entry UI. When a student enters the code, the app writes an attendance entry. The backend function checks the code and T-window (e.g. 5 minutes) before confirming.

```
flowchart LR
  Start[Start Class] --> Gen[Faculty taps 'Generate OTP']
  Gen --> Store[Firebase stores (otp, timestamp)]
  Store --> Notify[FCM alerts students]
  Notify --> Entry[Students enter OTP]
  Entry --> Validate[Firebase validates OTP & time]
  Validate -->|Correct| Success[Mark Attendance ✓]
  Validate -->|Wrong/Expired| Error[Reject Entry ✗]
  Success --> End
  Error --> End
```

Fig. 2. OTP-based attendance workflow.

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Firebase Database Schema:

We modeled the Firebase DB with collections for Users, Courses, Attendance, etc. A simplified ER diagram (Fig. 3) shows key nodes. Each Course node contains an attendance/{date}/[studentID] list of present students, plus current otp and otpTimestamp. User nodes have profiles (role, enrolled courses).

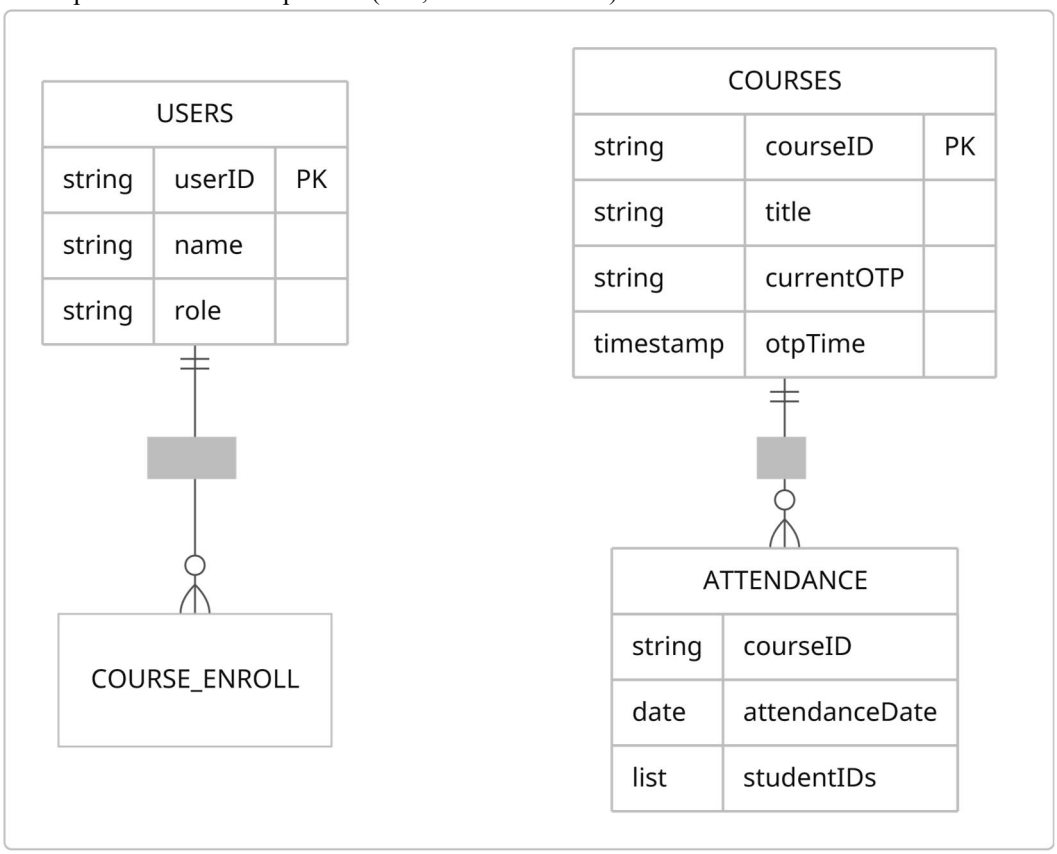

Fig. 3. Firebase database ER diagram (keys: PK=primary key).

IV. METHODOLOGY

The SmartERP system was developed using Android Studio with Java and XML for the frontend, while Firebase was used as the backend service for authentication, real-time data synchronization, and cloud storage. The system follows a modular architecture consisting of attendance management, authentication, academic services, and an AI-assisted chatbot.

• Attendance Module: Faculty members generate a unique six-digit OTP for each lecture through the application. The generated OTP is stored in Firebase Realtime Database along with its validity period. Students enter the OTP on the attendance screen, where the system verifies the code and its expiration time before recording attendance. This approach minimizes proxy attendance and ensures that only valid OTPs are accepted during the active session.

• Firebase Database: Firebase Realtime Database stores information related to users, courses, attendance records, study materials, announcements, marks, and feedback. The database is organized by course and academic records, enabling efficient retrieval and real-time synchronization across student and faculty applications.

• Authentication Module: Firebase Authentication provides secure login for both students and faculty members. Based on the authenticated user's role, the application grants access only to the corresponding features and dashboards.

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• ERP Services: The SmartERP application provides integrated academic services, including attendance management, study material sharing, announcements, marks management, notifications, and student feedback. All updates are synchronized instantly through Firebase, ensuring that users always access the latest information.
• AI Chatbot Module: An AI-powered chatbot is integrated into the application to assist students with academic and ERP-related queries. The chatbot processes user questions using an LLM API and provides relevant responses based on the available academic information, improving accessibility to institutional resources.

V. IMPLEMENTATION DETAILS

The SmartERP Android application was developed using Java and XML, with Firebase providing backend services for authentication, real-time data synchronization, and cloud storage. The application consists of separate interfaces for students and faculty, ensuring role-based access to system functionalities. The faculty dashboard enables attendance management, OTP generation, and report access, while the student dashboard provides attendance marking, academic notifications, study materials, and chatbot assistance.

OTP Module: A unique attendance verification code is generated by the faculty for each lecture and stored in Firebase Realtime Database along with its validity period. Students enter the generated code to mark their attendance, and the system validates the code before recording attendance. Once the validity period expires or attendance is stopped by the faculty, the code becomes invalid for further use.

Authentication Module: Firebase Authentication is used to manage secure user login. The system distinguishes students and faculty based on their registered roles, allowing users to access only the features assigned to them.

AI Chatbot Module: The SmartERP application integrates an AI-powered chatbot that assists students by answering queries related to attendance, academic information, study materials, and ERP services. User queries are processed through an LLM API, and relevant information is retrieved from the system database whenever required to provide contextual responses.

The project was managed using GitHub for version control, enabling collaborative development and efficient tracking of source code changes. Technical documentation and user guidelines were also prepared to support system deployment and future maintenance.

VI. RESULTS AND DISCUSSION

A The SmartERP application was successfully developed and tested in a college environment to validate the functionality of its core modules. The system integrates secure user authentication, OTP-based attendance marking, attendance management, Firebase real-time synchronization, notifications, and an AI-powered chatbot within a single platform.

During functional testing, the attendance workflow operated as intended. Faculty members were able to generate attendance codes, and students successfully marked their attendance using the generated OTP. The system validated each request before recording attendance and updated records instantly through Firebase Realtime Database. Faculty members could also access attendance reports and manage student records without manual intervention.

The AI chatbot module was integrated to assist students by answering queries related to attendance, academic information, and ERP services. The chatbot generated context-aware responses based on the available institutional data and improved the accessibility of academic information. The current implementation demonstrates the feasibility of integrating generative AI into an educational ERP system. Further optimization and comprehensive performance evaluation will be carried out in future work.

Overall, the experimental implementation confirms that SmartERP provides a unified and user-friendly platform for attendance management and academic support. The integration of cloud services and AI capabilities reduces manual effort, improves data accessibility, and simplifies communication between students and faculty.

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Table I. Functional Evaluation of SmartERP

Module	Observation
User Authentication	Successfully verified user access
OTP-Based Attendance	Attendance recorded successfully after OTP verification
Firebase Synchronization	Attendance records updated in real time
Attendance Management	Faculty could view and manage attendance records
Notification Module	Notifications delivered successfully to users
AI Chatbot	Successfully responded to academic and ERP-related queries
Overall System	All core modules operated as expected during testing

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