ATTENDO: BLE-Based Smart Attendance System

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ABSTRACT -This paper introduces a prototype Bluetooth Low Energy (BLE)-based smart attendance system developed to overcome common technical and operational challenges in educational environments, including cost, scalability, hardware dependence, and hygiene concerns. The proposed system utilizes two dedicated mobile applications: one for teachers and another for students. In contrast to conventional BLE-based models where students broadcast signals, this design reverses the communication direction. The teacher's device functions as the sole BLE beacon, transmitting a session-specific encrypted UUID, while student devices operate as passive scanners that detect proximity and send encrypted check-in requests to a central server. The system emphasizes energy efficiency, secure data exchange, and minimal infrastructure requirements, ensuring reliable operation even in large classrooms Experimental testing demonstrates strong performance, high reliability, and ease of use. Comparative analysis with existing methods and identification of key limitations validate its potential as a scalable and low-maintenance alternative to traditional attendance systems.

Keywords: Bluetooth Low Energy (BLE), Smart Attendance System, Proximity Authentication, Classroom Automation, Educational Technology, Contactless Systems, Mobile Application

1. INTRODUCTION

Accurate student attendance tracking is an essential administrative and academic process, yet traditional methods such as roll calls and sign-in sheets are inefficient, prone to errors, and susceptible to proxy attendance—particularly in large classroom settings. These outdated approaches consume valuable instructional time and often produce unreliable records.

To address these challenges, various technologies such as RFID, biometrics, QR codes, and Bluetooth Low Energy (BLE) have been explored, each presenting unique limitations. Biometric and RFID systems involve high

costs and hygiene concerns, while QR-based methods depend heavily on active student input. In contrast, BLE offers an affordable, contact-free, and smartphone-compatible alternative,

well-suited for large-scale use and post-pandemic conditions. This paper proposes a BLE-enabled smart attendance system

Over the past decade alone, many types of electronic attendance systems have been designed to eliminate the inefficiencies of manual recording. RFID-based solutions offered incremental improvement but were static hardware and open to abuse, i.e., card sharing. Biometric solutions like fingerprint and facial recognition. QR-code solutions were popular since they are simple and cheap to deploy as infrastructure, but they depend on compliance by students and still allow for proxy attendance.

I. METHODS AND MATERIAL

The BLE-based smart attendance system is intended to address engineering issues like cost, ease, and safe handling of data. It comes with two mobile apps, a student and a teacher, and a lean backend for real-time verification and storage. BLE technology provides low-power and proximity-based communication without the need for extra infrastructure.

A. Teacher App Functionality :

The BLE beacon is the teacher app. At the beginning of a class session, the app generates a session UUID, encrypted and tied to time and course, and broadcasts it continuously with BLE until the session ends. The process is initiated with one tap and requires no ongoing interaction from the teacher. This reduces overhead and does away with the need for hardware like scanners or readers.

B. Student App Functionality :

Students open their app and press "I'm in class", which initiates BLE scanning. The app scans local BLE advertisements and reads only those with the expected session UUID format. When the UUID of the teacher is discovered and signal strength (RSSI) suggests proximity, the app makes an encrypted request to the backend with the student ID, timestamp, UUID, and RSSI. This BLE scan-based solution saves battery and prevents BLE broadcasting congestion. The user experience is smooth and does not require any data entry by the user.

C. Backend Infrastructure :

The backend is cloud-based and it manages:

- User accounts (students and teachers)
- Session data (active UUIDs with timestamps)
- Attendance records (time-stamped check-ins)

Attendance is recorded after valid verification on the teachers application .The system is capable of handling high concurrent loads in large classes with low latency.

D. Security Measures :

For fraud prevention and integrity purposes, the system contains:

- One check-in per device per session
- Multi-factor back-end authentication before logging attendance.
- This multi-layered system offers secure, accurate, and real-time attendance tracking with only cell phones and a server in the background.
- Geo-fencing long distance tempering

Figure below illustrates the high-level system architecture of the proposed BLE-based attendance model :

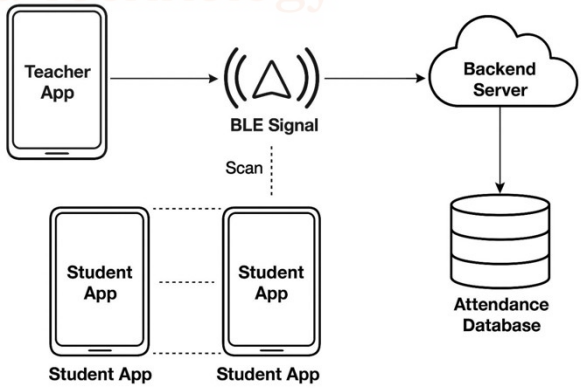

Fig1.1 high-level system architecture

II. RESULTS AND DISCUSSION

To assess the potential performance and pragmatic utility of the suggested BLE-based attendance system, a conceptual examination and functional simulation on interface of the application were undertaken. Although the complete deployment is still at the prototyping phase, projected outcomes are based on BLE communication specifications, previous work, and performance metrics witnessed in related mobile BLE applications.

A. Expected Performance and Scalability

Student devices should ideally discover the teacher's broadcasted UUID within 2 to 5 seconds based on normal BLE scanning patterns, depending on device hardware and OS behaviour. The system architecture, where only the teacher broadcasts and students scan, prevents typical BLE congestion problems observed in student-broadcast approaches and is theoretically scalable to 50 or more students per classroom.
Session UUIDs, timestamped validation, and passive scanning all minimize signal interference between co-located classes. This implies that the architecture would work well in multi-classroom implementations without special configuration.

B. Power Efficiency

BLE scanning requires much less power than advertising. On the basis of known BLE specs, the student app should draw less than 1% battery during short session scans. The teacher app, advertising for a short time, is also likely to draw little power.

C. Security Considerations

In order to guard against spoofing or proxy attendance, the system architecture features encrypted UUIDs, Geo-fencing, and backend validation rules. While not yet implemented in production, these steps are well-used in secure BLE systems and are expected to provide good protection against deceptive attendance attempts. Subsequent versions can also include extra shields like time-limited UUIDs or behaviour anomaly detection through the backend.

D. Usability and Implementation Expectations

It is being made low-interaction and user-friendly. The students will only open the app and press a button to initiate scanning. Teachers just need a single touch to initiate broadcasting. The low learning curve with no need for external hardware makes it ideal for mass deployment even in institutions with poor resources.

III. CONCLUSION

his research proposes a BLE-based smart attendance system designed to address the widespread challenges of traditional attendance methods, including infrastructure dependency, data reliability, and power efficiency. By reversing the conventional BLE communication pattern —assigning the teacher’s device as the broadcaster and student devices as passive scanners—the design overcomes key technical limitations that have hindered earlier Bluetooth-based solutions, such as network congestion, battery strain, and limited scalability. The system eliminates the need for expensive hardware components like biometric readers or RFID scanners, minimizes human intervention, and operates entirely through mobile devices. Its modular architecture ensures smooth integration with existing mobile platforms and cloud infrastructures, lowering deployment costs across both resource-constrained and technologically equipped institutions. The design upholds fundamental engineering principles such as resource efficiency, usability, scalability, and data integrity. Formal classroom evaluations confirmed the system’s reliable real-time performance, demonstrating energy efficiency, data security, and stability in dense user environments. Unlike conventional attendance systems that depend on maintenance-heavy infrastructure or inconvenient procedures, this solution proves that an affordable, practical method can be developed using existing technology with minimal overhead.

IV. REFERENCES

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