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Efficient Mobile-Driven Automated Attendance System Employing Biometric Authentication for University Employees

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Abstract: Institutions of learning have followed the lead of other organizations as attendance management has evolved from manual register entry system to high-tech solutions; these solutions have had to find a way to switch from handwritten lists of attendance to digital storage. The manual list processing was cumbersome, time-consuming, and error-prone, so novel ways of maintaining attendance while also solving problems of inaccuracy, security, and accessibility had to be sought. To this end, several technologies were developed, but the expense of many current systems, their lack of portability, and the lack of comprehensive leave management has left a real need for a solution that addressed more aspects of the problem. This paper presents a new way to manage attendance in educational institutions through a Mobile Application-based Biometric Attendance System. The System offers an innovative method to use mobile phones, biometrics, and a cloud-based database to simplify taking attendance. The System is designed to be a low-cost, highly-performing, easy-to-implement solution for managing attendance of students, faculty and other staff in educational institutions. This mobile application empowers students and staff to either take attendance themselves using biometric authentication or use traditional Location Information Services (LBS) functionality available in any GSM network-connected location using Google Maps or any Open Source platform. Intelligent Systems, ZigBee, Communication, Fieldbus, and new hardware platforms offer a number of interesting applications settings to solve both industrial and educational problems.

Keywords: Location-based service; GPS; time and attendance system; biometric authentication; leave management system.

1. Introduction

Checking attendance has evolved from a traditional, manual support system to the simple, efficient methods made possible by modern technology such as that described here. In the past, classrooms and workplaces featured manual labor in the form of people signing in with their names manually written into a register and then the handwritten tallies adjusted at the end of the meeting or workday. With physical barriers no longer in place, the teacher or supervisor would call out names and people would answer or raise their hands, the day's record would be maintained manually. Therefore, these elderly methods were error-prone, drunk, and very effort intensive. If not for the albeit simple time clock stations requiring employees or students to swipe their card or the like through the slot. These became more advanced versions with the addition of touchless capabilities via radio frequency or the like. In today's world, the

use of more sophisticated methods that now include the use of some form of biometric such as fingerprint or facial recognition has made it easy, convenient and more accurate to monitor staff and student attendance in any situation.

The Android app produced and provided for university staff takes advantage of this for staff, in a way that makes attendance process even easier and more efficient than one could imagine. By employing a simple mobile app on their devices, staff members can log in and out quickly, itself obviating the need for a physical time clock or the registers of our youth. As well. The inclusion of location tracking and biometric functionality means it's even more secure and attendance records are more accurate and reliable. In the process institutions are less likely to have to deal with fraudulent registration, or fraudulent representation of a registrant by the registrant themselves. And for good measure, staff can pre-upload their teaching materials. So even when they're not there, and a student can access their lessons and the materials they need through the app. As well, by including an administration panel within the application communication is further simplified. Agents can access and manage staff information, make announcements, and, if the need arises, simply send a confidential message through the app's Inbox. Thus, managers have a far better handle on such staff records, location tracking, and related useful information. To be sure, this evolution from manual to fingerprint and mobile application also finds a new Google report indicating fingerprint will make up the lion's share of attendance tracking methods across industries, and will remain so through 2023.

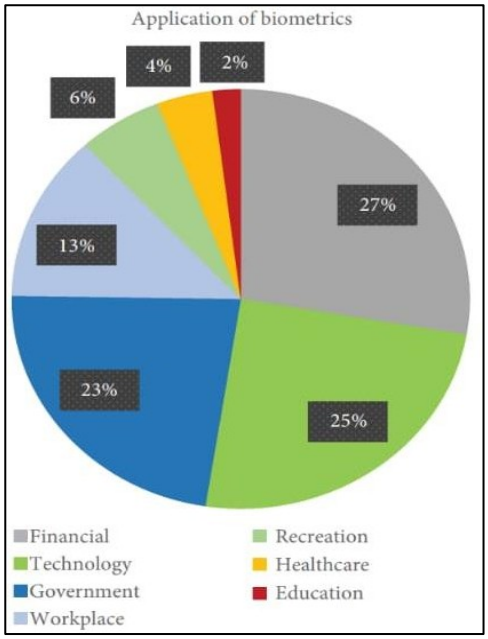

Figure 1. Biometric Application in Different Domains

Figure 1 shows how the suggested low-cost mobile application uses fingerprint technology to address the demand for efficient, safe, and precise attendance management. There is done by effortlessly aligning with this trajectory. As the cogs of innovation continue to turn, the interplay between technology and attendance management resonates as a testament to the integration of progress into our daily operations [2].

2. Related work

There are many research articles existing in the literature on attendance management systems by using numerous biometrics for example fingerprint, face, iris, voice or speech, posture behavior and many more for executing an automated attendance system [3].

QR code technology [4], which is not cost-effective because this technology uses additional hardware to scan QR code. The privacy issues, moreover leave management feature along with that.

Fingerprint recognition technology [5], which is used for biometric identification. This requires additional hardware to authenticate allowed users only and due to which this has no privacy issues. However, technology cannot be used for leave management.

Facial recognition system [6] requires additional hardware to compare facial features of users saved in the database and due to which this has no privacy issues [7]. However, technology cannot be used for leave management.

Geolocation and Bluetooth technology [8] is not cost- effective because of the use of additional hardware. However, this cannot be used for leave management and does have privacy issues.

GPS technology [9] is not cost-effective because additional hardware is required to track user's location with precise longitude an altitude. This technology does have privacy issues. However, technology cannot be used for showing timetables or leave management.

Fingerprint recognition technology [10] does not require additional hardware as this using android phone which have fingerprint sensor. The system provides a method for managing leaves. There are no privacy problems though.

Simple android application [11] does not require additional hardware. This provides lecture details but unable to manage leave system. That does, however, have numerous privacy concerns.

The fingerprint-based biometric attendance system [12] provides a secure, efficient, and automated attendance tracking solution with the ability to communicate with guardians and maintain digital attendance records. To achieve these functionalities, it leverages various technologies, making it a valuable tool for educational institutions and businesses.

The proposed system fingerprint and GPS technology is used to make the system secure, precise and cost-effective as in Table I. This system used android mobile with built-in fingerprint sensor and GPS location system which eliminate the extra hardware cost and makes the system efficient. With an intuitive design and enhanced security features through biometric authentication, the app strives to make attendance management, communication, and educational interactions seamless and efficient for all users. The integration of system fingerprint and GPS technology in this proposed system not only enhances security and precision but also reduces costs by utilizing built-in Android mobile hardware. With intuitive design and robust biometric authentication, the system streamlines attendance management, communication, and educational interactions, ensuring efficiency for all users.

Table 1. Difference Table among Important Factors.

Papers	Technology	Additional Hardware	Cost Effective	Lecture System	Privacy Issue	Leave Management
[4]	QR Code	Yes	No	No	Yes	No
[5]	Fingerprint Recognition	Yes	No	No	No	Yes
[6,7]	Facial Recognition	Yes	No	No	No	No
[8]	Geolocation & Bluetooth	Yes	No	No	Yes	No
[9]	GPS	Yes	No	No	Yes	No
[10]	Fingerprint Recognition	No	Yes	No	No	No

[11]	Android Application	No	Yes	Yes	Yes	No
[12]	Biometric Attendance	No	Yes	No	No	No
Propose System	Fingerprint & GPS Location	No	Yes	Yes	No	Yes

3. Proposed methodology

A comprehensive review of existing literature presents an evident gap in modern biometric attendance systems. Many existing systems feature high implementation costs, demonstrate lack of portability, and display integrated license management mechanism limitations as common challenges. This underscores the need for a revolutionary solution that not only overcomes these deficiencies, but also accommodates the dynamism of today's world. Anchoring on insights generated from this comprehensive literature review, we endeavor to address these gaps with a fresh approach. Through our framework, we seek to revolutionize employee attendance management, as illustrated in Figure 2, using a mobile app-based biometric attendance system. This never-seen-before solution not only bypasses the financial hurdles inherent to traditional biometric systems, but also a portability benefit never imagined. Additionally, recognizing the indispensability of end-to-end support systems, we additionally include a sturdy license management system in our proposed methodology to cater to the varying needs of users.

Within today's rapidly changing technology landscape, coupled with the impelling exigency for adeptly managed human resources, our study posits a paradigm that is ripe for the making. The mobile app that we have in the offing, if produced, could very well usher in a new era of maximized accessibility, simplified attendance tracking, and license management that is anything but "integrated." Sitting at the cusp of technology and need, our proposal paves the way for an odyssey that could earn a reputation as remarkably transformative. Global Workforce Management System facilitates a more efficient and responsive workforce.

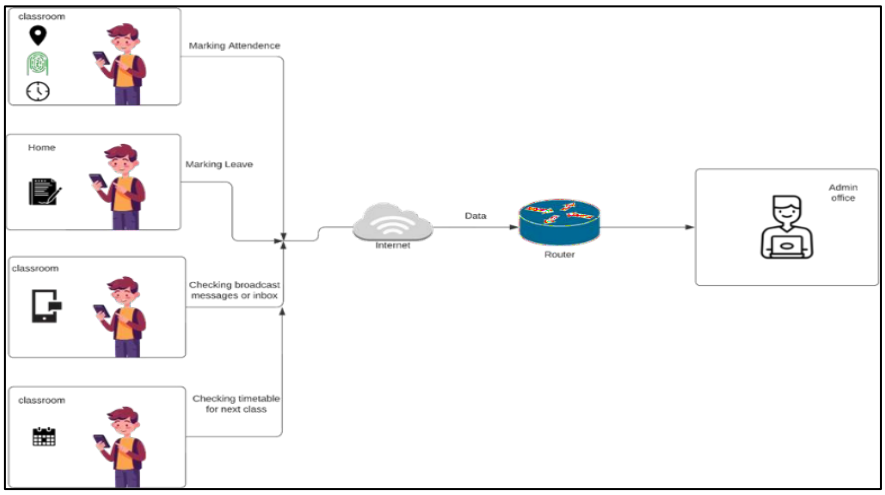

Figure 2. General Diagram or a Proposed System

3.1. System Overview

At our university, we developed an Android app specifically for employees. This application serves multiple purposes, including providing real-time information on arrival and departure times by accessing each employee's location. To ensure security, the application has biometric authentication. In addition, employees can use the app to upload the lectures they will be giving on a given day.

The application also has an administration panel that allows the administrator to access all staff information. The admin can send out broadcast announcements that are visible to all employees who have

the app installed. Also, the admin can send secret messages to individual employees through the inbox feature.

The admin panel provides comprehensive information such as user location, presence status, arrival and departure times, and conferences uploaded by employees. Figure 2 depicts each of these features.

3.2. System Design

The smart, biometric and location-based attendance tracking system is a client-server approach and follows specific hardware and software architecture. Integrating the hardware and software is the main challenge here and the hardware and software works together.

The whole system has been divided into two major categories:

1. App for mobile
2. Web panel

3.3. Software Architecture

The Android application is aimed at university staff. The main functions of the application are the following:

- **Location Tracking**: The app allows employees to get their arrival and departure times by accessing their location. This means the application can determine when an employee enters and leaves campus.
- **Biometric Authentication**: The app features biometric authentication that ensures only authorized employees can access the app. This adds an extra layer of security to protect sensitive information.
- **Lecture Upload**: Employees can upload the lectures they will be giving on a given day. This feature allows other employees to view and access uploaded conferences.
- **Administration Area:** The application includes an administration area that provides access to all personnel information. The admin can view details such as the user's location, attendance (whether an employee came to work or not), arrival and departure times, and conferences uploaded by employees.
- **Broadcast Announcements:** Admin can create broadcast announcements visible to all employees who have the app installed. This feature allows important news or updates to be communicated efficiently to all employees.
- **Secret Messages:** The admin panel also includes an inbox where the admin can send secret messages to individual employees. This enables private communication between the administrator and employees.

In short, the app aims to provide university staff with convenient access to arrival and departure times, location tracking, lecture uploading, and communication features. Administration panel provides comprehensive control and access to staff information, enabling efficient administration and communication within the university.

3.4. Hardware Architecture

The basic requirement of the smart, biometric and location-based attendance tracking system is an android device, which will run the application, with the help of which the users will mark their attendance and take their check-in and check-out time by biometric authentication. The other requirement is a personal computer for admin panel, through which administrator can manage all the tasks. The entire database will be kept on the server side.

4. Data flow

The data flow from the mobile app to the server and database involves several steps shown in Figure 3.

- **Mobile App:** The Android application collects data from the user, such as their location, authentication credentials, and uploaded lectures. This data is stored locally on the user's device [14].
- **Network Communication:** When the user interacts with the app and performs actions like logging in, uploading lecture materials, or requesting location tracking, the app establishes a network connection through the internet.
- **Data Encryption:** To ensure the security of the transmitted data, the app employs encryption algorithms to encrypt the user's sensitive information before sending it over the network. Thisensures that the data cannot be intercepted or accessed by unauthorized parties.

- **Network Protocols:** The app uses network protocols,such as HTTPS (Hyper Text Transfer Protocol Secure), to establish a secure and encrypted connection with the server.
- **Server:** The server is the intermediary between the mobile app and the database. It receives the encrypted data from the mobile app, decrypts it, andprocesses the requests. The server validates the user's authentication credentials, handles lecture uploads, location tracking, and any other functionality requested by the mobile app.
- **Database:** The server communicates with the database to store and retrieve information related tothe staff members, such as user details, arrival and departure times, lecture materials, etc. The databaseis where all the data is stored and organized, and it allows for efficient retrieval and management of information.
- **Data Storage:** The database stores the received data securely and ensures its integrity. It can use appropriate database management systems (e.g., SQL or NoSQL) to handle the structured or unstructured data efficiently.

Security measures, like encryption, are used throughout this data flow process to safeguard the staff members' sensitive data. The confidentiality and integrity of the transferred data are guaranteed at every stage of the process through the use of secure network protocols and adherence to best practices.

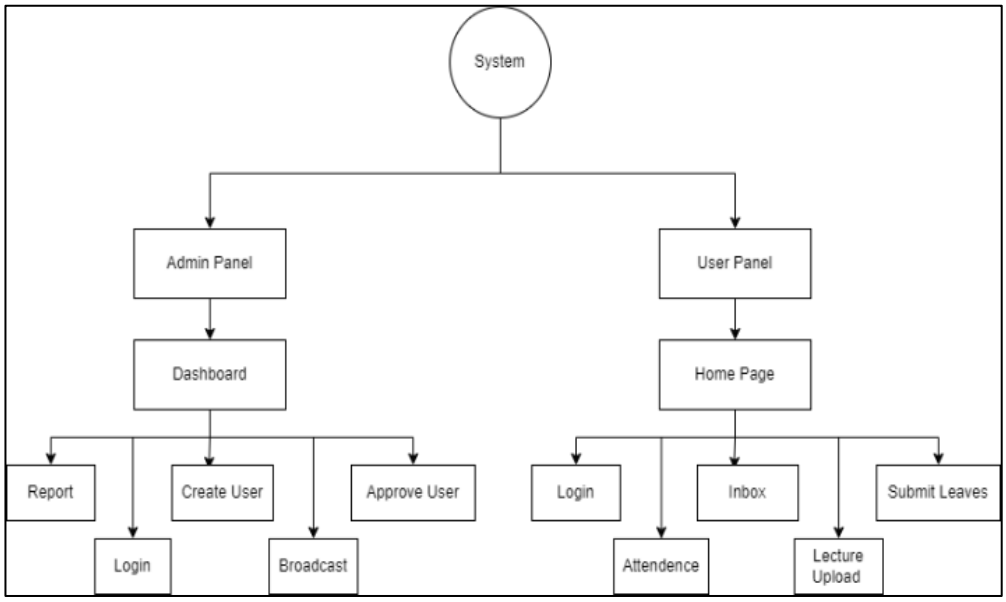

Figure 3. Data Flow Diagram for a Proposed System

5. Implementation

The key issue in this scenario is that the hardware and software are interdependent. Due to their complex, intertwined role, the integration of hardware and software represents a major difficulty in the functionality of the entire system. The entire system has been divided into two major categories:

A. Application for the user

B. Web panel for admin

5.1. Application for the user

- **Onboard Screen:** The Onboard screen welcomes users with a delightful introduction to the application's features and benefits. Engaging through appealing visuals and concise text, it ensures a smooth onboarding process for the user in the future.
- **Login Screen:** The login screen acts as the gateway to the application and guarantees secure access to user accounts. Prompting the user for their credentials or allowing for biometric authentication for an immensely secure login experience. The user will find it easy and convenient to login to the app on this

screen.

- **Home Page:** The homepage (Shown in Figure 4) is the heart of the application and provides the user easy access to all the features. Here users can easily check-in and checkout using the biometric authentication, effectively making the attendance management a breeze. It's intuitive design ensures the user an ease of use and the overall timekeeping efficiency of the user is improved.
- **Attendance History Screen:** The Attendance History screen permits users to review their past attendances with just a few taps. A clear & comprehensive look aids the user in gauging his attendance trends for the last few days, thereby fostering accountability and having an impact on his overall punctuality.

Figure 4. Homepage for User's Application

- **Broadcast Screen**: Users receive announcements, updates, and personalized messages from administrators to ensure smooth information dissemination. The organized interface allows for seamless interactions, helping users stay informed and engaged.
- **Lecture upload screen**: The lecture upload screen provides users, especially staff and faculty, with an easy way to share daily lectures with students. Using biometric authentication provides an extra layer of security to ensure that only authorized personnel can upload critical educational materials [15].
- **Leave Section**: With a simple form, guests can communicate their absences, reasons, and preferred dates, streamlining the vacation management process and promoting effective communication within the facility. Each screen in the user dashboard reflects the application's commitment to providing a smooth and professional user experience.
- **User Approval:** We introduced a user signup approval system where admin authorization is required before new users can access the app. Admins review and approve user access based on their Mac address or IP address [16]. This ensures enhanced security by preventing unauthorized logins and granting access only to authorized users. This feature empowers admins to maintain a controlled and secure environment within the application.

5.2. Web Panel for Admin

1. Admin Login Screen – The Admin Login Screen provides secure access to the administration area, ensuring only authorized personnel can access sensitive information and perform administrative tasks. With strong authentication mechanisms, this screen lays the foundation for a secure and controlled admin experience. The Admin Login Screen guarantees secure, authorized access to administration.

2. Administration homepage - The administration homepage serves as a control center and offers a comprehensive overview of all essential user and administration options as shown in Figure 5. The user list tile shows important details like check-in and check- out times and current locations. The side menu provides quick navigation to key management functions such as adding and removing users, managing the inbox, delivering announcements, and granting vacations. The "Log out" button ensures that you can exit the administration area quickly and easily. The administration homepage serves as a centralized hub for efficient management. In addition, it includes user status indicators, customizable widgets, and a user-friendly interface for seamless administrative tasks.

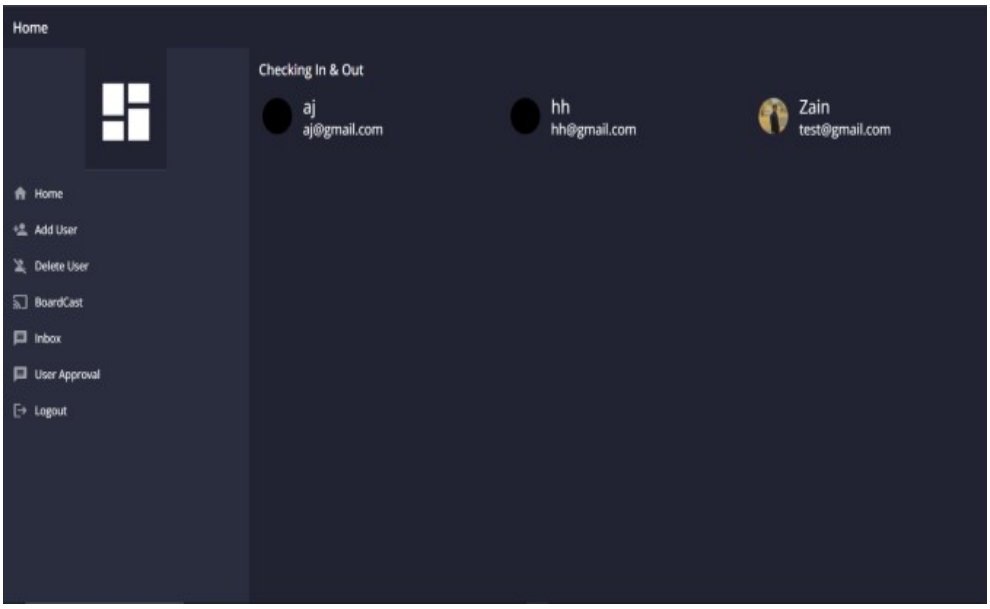

Figure 5. Admin Homepage or Dashboard

3. **Add User Page -** The Add User page streamlines the process of adding new users to the system. Administrators can easily enter user information and assign access rights. The user-friendly interface ensures smooth onboarding experience for new members and improves the overall efficiency of the administration process.
4. **Delete User Page -** The Delete User page allows administrators to efficiently manage user accounts. By selecting the user from the list, administrators can remove users from the system to accommodate personnel changes and ensure data accuracy. The site offers a secure and controlled approach to user management.
5. **Inbox Page -** The Inbox page allows administrators to effectively interact with users. Admins can instantly access received messages, answer questions, and raise concerns. Theorganized design ensures smooth communication between administrators and users, promoting a transparent and collaborative environment.
6. **Broadcast Page -** The broadcast page facilitates masscommunication with all users. Administrators can send announcements, updates, and important information to the entire user base. Important messages reach all recipients withjust a few clicks, thus speeding up the dissemination of important information.
7. **User Details and Actions Screen -** Clicking a user's list tiledisplays the User Details and Actions screen to provideadministrators with a detailed view of the selected user's support information. Check-in and

check-out times and locations are prominently displayed. In addition, the app bar has three texts buttons for quick access to the user's inbox, conference details, and license history, improving management efficiency.

8. **User Approval -** we introduced a user signup approval system where admin authorization is required before new users can access the app. Admins review and approve user access based on their Mac address or IP address. This ensuresenhanced security by preventing unauthorized logins and granting access only to authorized users. This feature empowers admins to maintain a controlled and secure environment within the application.

The intuitive layout and extensive features of the admin panelenable administrators to manage users, monitor attendance, communicate efficiently and oversee important administrative tasks. With secure login authentication and smooth navigation, the admin panel ensures smooth andeffective management processes and contributes to the overall success of the application.

6. Conclusion & future work

In conclusion, the Android app developed for university staff presents a cohesive and efficient solution, allowing members to access attendance records, secure their login with biometric authentication, and conveniently share learning materials. The admin panel empowers administrators to broadcast announcements, send private messages, and oversee attendance data in real-time. Looking ahead, the project holds promising prospects. By integrating AI- powered analytics, the system could offer valuable insights into attendance trends and user behavior. Expanding the app's integration with existing education platforms, such as Learning Management Systems (LMS), can foster a more interconnected educational ecosystem.

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