A Mobile Fingerprint Biometrics Attendance System for University Lectures

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***Abstract*— One of the challenges in many universities today is how to collate and maintain accurate attendance records. There are usually issues of impersonation by students and too large a number of attendance sheets to collate at the end of a session or semester. However, there have been several attempts to solve this problem through biometric attendance taking. But many of them have to be installed permanently in classrooms, and need a constant power supply, which leads to them not being portable and hence higher costs of installation in all available classes. This work presents the design, implementation and evaluation of a mobile, smartphone-based Bluetooth fingerprint attendance system. The system is made up of a wireless fingerprint scanner, an Android app and a web dashboard for managing attendance data. The system was evaluated in the Department of Computer Science and Engineering, OAU, with 85 students. The metrics for testing were the False Acceptance Rate (FAR) and False Rejection Rate (FRR). The system recorded a FAR of 0%, which means no unauthorised access was accepted, and a FRR of 17.6%, which means 17.6% of genuine fingerprints were rejected. It took an average of 10 seconds to enrol each student and an average of 6 seconds to mark their attendance.**

Keywords—Biometric Attendance, Fingerprint Recognition, Bluetooth, Mobile Application, Universities

I. INTRODUCTION

Taking attendance is important in many tertiary institutions. Many institutions also have attendance rules. For example, at Obafemi Awolowo University, 70% attendance is a prerequisite to be eligible for examinations [1]. The process of taking attendance in academic environments like universities is usually laborious, insecure and susceptible to errors. Manual methods such as paper-based registers or roll-calls can consume much time, and several students also impersonate others. [2]. Some of the existing digital solutions are not portable for reuse across several classrooms and need permanent installations, leading to higher deployment costs, while some require a constant power supply for the system to work effectively.

The lack of accurate attendance data reduces academic assessment integrity and creates administrative burdens in the manual compilation and verification of attendance records. Furthermore, several existing commercial solutions require costly and dedicated hardware that several universities may not be able to afford or maintain, leaving these institutions to continue with the heavily flawed manual process of compiling attendance records.

Fingerprint recognition has proven over time to be a reliable way of identifying people. [3]. Several automated attendance systems have also been developed using fingerprint sensors integrated with microcontrollers like Arduino or Raspberry Pi [4, 5]. However, several of these systems are not portable. Some of them require fixed installation at classroom entrances and a constant power supply. This leads to an increase in costs [6].

This paper proposes a portable Bluetooth fingerprint scanner, an Android application, and a web dashboard to create a flexible, cost-effective, and efficient attendance management system. The objectives of this work are:

1. Design the system architecture of a fully wireless, portable biometrics attendance system.
2. Develop the interfaces for both the Android app and the Web dashboard.
3. Integrate fingerprint capture, recognition, with the mobile and web interfaces and;
4. An evaluation of the system's usability and performance in a real-world university setting.

This research was conducted in four phases according to the specific objectives. The first phase involved designing the system architecture and user interface. The requirement analysis was obtained through a survey using a questionnaire to lecturers in order to identify functional requirements and expectations.

The second and third phases focused on the implementation and integration. The Android mobile app was developed using the Kotlin programming language and the Android Software Development Kit for student enrollment, fingerprint capture, attendance marking and local data management. The web app was developed using React JavaScript, providing the interfaces for course management, student registration, attendance monitoring and report generation.

The last phase was the evaluation of the system through a pilot test in the Department of Computer Science and Engineering. Time to register and verify, False Acceptance Rate (FAR) and False Rejection Rate (FRR) were some of the metrics used to determine the system's efficiency, accuracy and practicality for deployment in university environments.

II. LITERATURE REVIEW

Because of the usual high enrolment and class sizes in the tertiary institutions, effective organisation is needed for effective teaching and learning. Students' class attendance is positively linked with academic performance, better exam

performance and final course grades [7]. Research shows that by attending classes, students can participate effectively in class teaching, learn material, improve academic potential, and absorb implicit knowledge from peer-teacher interaction [8]. Student class attendance is therefore an indicator of commitment and is usually a prerequisite for progressing in most schools. Pupils' attendance in school and past academic achievement strongly influence their attainment and academic performance. [9].

Traditional methods of recording student attendance in tertiary institutions are primarily manual in nature, with the most common approaches being roll calls and the circulation of attendance sheets. These methods have served as the foundation for attendance management across higher education and, despite technological advances, continue to be widely practised in many institutions globally [10]. While these manual systems are simple and inexpensive, they have several limitations. Valuable class time, which could have been used for teaching or other important class activities, is wasted in roll calls by the lecturer. [11]. There is also the challenge of impersonation, where students sign on behalf of absent peers, undermining both the integrity of attendance records and the institution's ability to reliably monitor student engagement. [7].

Contemporary tertiary institutions require attendance management systems that are efficient, accurate, and secure. These requirements have made tertiary institutions explore technological solutions beyond traditional paper-based or simple digital systems. [12] mentioned some of these approaches in Figure 1.

Swain et al. [14] designed a system which consists of an Arduino microcontroller and an R305 fingerprint sensor, which is connected to an Android phone through a USB cable. Although the system was quite effective, the USB wired connection limits the portability of the system. Furthermore, the system does not provide for cloud storage and an administrative interface for managing attendance data.

Obiora et al. [4] Designed a Fingerprint-Based Attendance Monitoring System for the Department of Electrical and Electronics Engineering at Bells University of Technology, Nigeria. This was to replace the manual system of collation. This system employs an AS608 optical fingerprint sensor and an ESP8266 NodeMCU microcontroller to capture, verify, and document student attendance. The system works in two modes, which are: Register (to enrol fingerprints) and Record (to mark attendance). The system stores data in the cloud to ensure secure storage and access to attendance records. A real-time clock (DS1302 module) is used for timestamping attendance records. A web application was developed using React.js for administrative access and data management. The hardware features a portable design powered by 3.7V lithium-ion batteries. The system reduced the time used to mark attendance from 22.25 seconds in the manual method to 6.16 seconds per student. However, the system always requires a stable internet connection to take attendance.

No.	Method	Hardware	Software	Advantage	Disadvantage
1	Biometric Attendance	Fingerprint Reader, Retina Scan Machine	Custom Software, Server Software, DBMS	Automatic	Cost of Machine & Maintenance
2	RFID	RFID Reader, RFID Tags	Custom Software, DBMS	Automatic	
4	Facial Recognition	Infrared Camera, Server	Facial Recognition software, Server Software, DBMS	Automatic	
4	QR Code	Camera, QR or Barcode Scanner, Server	DBMS, Server Software	Sub- Automatic, Cheap	
5	Embedded Systems	Microcontroller (Arduino /ATMEGA), Single Board Computer (SBC) e.g., Raspberry Pi + Other Detection Technology	Server Software, DBMS	Automatic, Easily Deployable	Needs Expert to Operate

Fig. 1. Figure comparing existing technological approaches to attendance systems

Advancements in biometric technology have greatly simplified the process of capturing and storing individuals' fingerprints for authentication and verification purposes. Fingerprints are widely recognised as excellent identifiers because each person's ten fingerprints are unique, even among identical twins [3]. The accuracy of fingerprint recognition systems is commonly evaluated using two principal metrics: False Acceptance Rate (FAR) and False Rejection Rate (FRR). FAR represents the probability that a system incorrectly accepts an unauthorised individual, thereby compromising security. Conversely, FRR denotes the probability that a system incorrectly rejects a legitimate, authorised user, thus affecting usability. [13].

Badmus et al. [15] designed and implemented an attendance system that combines fingerprint biometrics and Radio Frequency Identification (RFID) technology. This was to improve security and efficiency in collating and maintaining attendance records. The system consists of: an Arduino Mega microcontroller, a card-based RFID reader identification system, a fingerprint sensor for biometric verification, a Real-Time Clock (RTC) for recording time, a Secure Digital (SD) card module for local data storage, and a Liquid Crystal Display (LCD) display. When the system was evaluated, the average attendance time recorded was 20.61 seconds, which is considered too slow compared to other existing solutions. It relies on both local storage via an SD card and cloud storage. Additionally, the system is entirely hardware-based and does not have any software interface for records management.

Olasupo et al. [16] created a Fingerprint-based Attendance Management System (FAMS) for Olabisi Onabanjo University to reduce the many problems that usually occur with manual paper methods, such as impersonation and inefficiency. This system makes use of a DigitalPersona fingerprint scanner to capture and authenticate unique fingerprints, and stores the templates in an SQL database through a C# -developed interface in Visual Studio. FAMS includes an administrative structure (institution → faculty → department → course allocation), real-time attendance recording via fingerprint verification, and automates the generation of attendance reports either daily, monthly or per semester. The major advantages were the elimination of impersonation, improved time efficiency by minimising roll-call delays, and a paperless approach that reduces costs. The system was tested in the Mathematical Sciences department, and the lecturers reported high accuracy during the capture of attendance and elimination of impersonation. However, the system is limited to relying on specific hardware (fixed fingerprint scanners) and the absence of mobile/web integration.

Talaviya et al. [17] introduced a wireless fingerprint attendance system that uses Zigbee technology to improve the management of students' attendance. This system consists of a portable fingerprint sensor module that connects to a central database through Zigbee wireless communication and features an LCD screen for real-time updates. Students take their attendance by placing their fingers on the scanner; the scanned fingerprint is compared with the pre-enrolled templates stored in a Microsoft SQL Server database. The system automatically generates Excel reports every 15 days. Emails are also sent to teachers, department heads, and parents. When the system was tested with 70 students. 92.8% success rate was reported. The system is portable as it makes use of mobile fingerprint sensors, which can be easily reused in other classrooms. But the system is quite rigid as attendance is only valid within 20 minutes after the lecture begins.

Rahman et al. [18] developed an automated fingerprint-based attendance system for Jatiya Kabi Kazi Nazrul Islam University's Computer Science department to fix the problem of manual roll-call when taking attendance. The system uses a minutiae-based fingerprint matching algorithm to quickly identify students and stores the templates in an SQL database. The major features of the system include a three-tier interface for admin, teacher, and students. Manual checkbox or biometric verification is also integrated, and automated report generation is also possible. Admins manage classes, and teachers mark attendance via fingerprint scans or manual entry. The system saves time by eliminating roll calls.

Zainal et al. [5] created and implemented a portable classroom attendance system that uses fingerprint biometrics and Arduino to solve problems like attendance fraud and the inefficiency of conventional paper-based techniques. The system is small, runs on batteries, and has a fingerprint scanner (ZFM20 module) to identify students. Real-time attendance recording, data encryption for security, and SD card storage are important features. Additionally, the device has a Real-Time Clock (RTC) module to timestamp entries and a touch screen for user interaction. Nevertheless, the system uses a memory card to store attendance data, which is susceptible to corruption. Furthermore, it lacked cloud storage and an administrator interface for improved access to attendance reports and records.

Tenuche et al. [19] introduced a biometric fingerprint attendance management system designed to overcome the shortcomings of traditional methods, such as paper sheets and proxy attendance, in universities. This system utilises a DigitalPersona U.Are.U 4500 fingerprint scanner for both enrolment and verification, connected to a desktop application created with Flexcode SDK and NetBeans IDE, along with a web interface tailored for administrators and lecturers. Students and lecturers register their fingerprints, which are saved in a MySQL database; attendance is captured when fingerprints are scanned during classes. The system also produces reports detailing attendance percentages and lecture counts, aiding institutions in implementing mandatory attendance policies, such as the 75% threshold required for exam eligibility. The system's strengths include high accuracy that prevents impersonation, minimises roll call time, and automated reporting that provides real-time data for stakeholders. However, there are limitations related to the reliance on desktop hardware (lacking mobile support) and possible bottlenecks caused by having only one fingerprint scanner per classroom.

Alassery et al. [20] designed and developed a smart classroom attendance system that combines Wireless Sensor Networks (WSNs) and Internet of Things (IoT). This system features smart chairs equipped with 50 kg load sensors and HX711 amplifiers to detect student presence through weight measurement, alongside a ZKTeco ZK4500 fingerprint reader for biometric authentication. An Android app (developed in Java) on lecturers' smartphones receives real-time attendance records, ensuring real-time attendance tracking. The system is quite innovative, but it is costly because custom chairs have to be built with special sensors. Even the fingerprint sensors are specific to the chairs, so the same sensors cannot be used in other classes.

Odulaja, G. O. [21] designed and developed the Fingerprint-Based Student Attendance Monitoring System (FiBSAMS) to solve issues found in manual attendance systems in Nigerian tertiary institutions. The system consists of an Atmega328P microcontroller, an RS305 fingerprint scanner, LCD/RGB Light Emitting Diode (LED) displays, and a database management system with pattern-matching algorithms for identifying and verifying students. FiBSAMS incorporated Admin, Lecturer, and Student submodules, each with distinct privileges. 100 students were tested, and the system had a 95% verification success rate, with failures mainly because of scarred fingers or wrong placement of the scanner. It took about 80 seconds to enrol each student, and 7 seconds to verify each student, which means the system was very fast. Although FiBSAMS is reliable and fast, it still requires stable electricity and specially trained administrators.

III. SYSTEM DESIGN AND METHODOLOGY

The goals of this project are accomplished through a methodical and structured approach that combines design

process, requirement analysis, architectural and database design, system integration, and performance metrics.

A. Requirements Phase

Functional requirements capture the system's intended behaviour, which may be expressed as services, tasks, or functions the system must perform:

- The system should be able to create new lecturer accounts and new classes
- The system should be able to capture students' fingerprints and register them
- The system should be able to recognise students' fingerprints and mark attendance
- The system should be able to communicate wirelessly with the mobile phone
- The system should be able sync with the cloud for data storage
- The system should be able to generate attendance reports on demand.
- The interfaces should be simple to navigate.

B. System Design

The high-level architecture, shown in Figure 2, consists of three main components:

1) Application Layer: This is the HF 4000 Plus optical wireless fingerprint scanner. It has Bluetooth 5.0 connectivity, a 10,000mAh built-in battery, which can power the scanner continuously for 10 hours. The scanner can also detect live and fake fingers, and it also supports multiple image formats such as ISO, ANSI and JPG.

2) Presentation Layer: The web dashboard allows administrators to view and create attendance reports, manage classes and students, while the Android application manages offline storage and fingerprint scanning.

3) Data Layer: Google's Firebase, which is a unified backend-as-a-service (BaaS) platform, was used as the backend and cloud storage for this project. Firebase provides a secure, scalable way of real-time synchronisation of both the Android application and the web dashboard. Both the app and the dashboard communicate directly with Firebase through the provided official SDKs.

C. UML Diagrams

The database, activity and use case designs are all illustrated using Unified Modelling Language Diagrams. UML diagrams are a standard visual modelling language used in software engineering to visualise and document the components of a software system. The UML diagrams are categorized majorly into structural diagrams and behavioural diagrams. Structural diagrams, such as class diagrams and framework diagrams, show the aspects of a system like its architecture, attributes and relationships. Behavioural diagrams, such as use case diagrams and sequence diagrams, show how the system responds to various events and user actions.

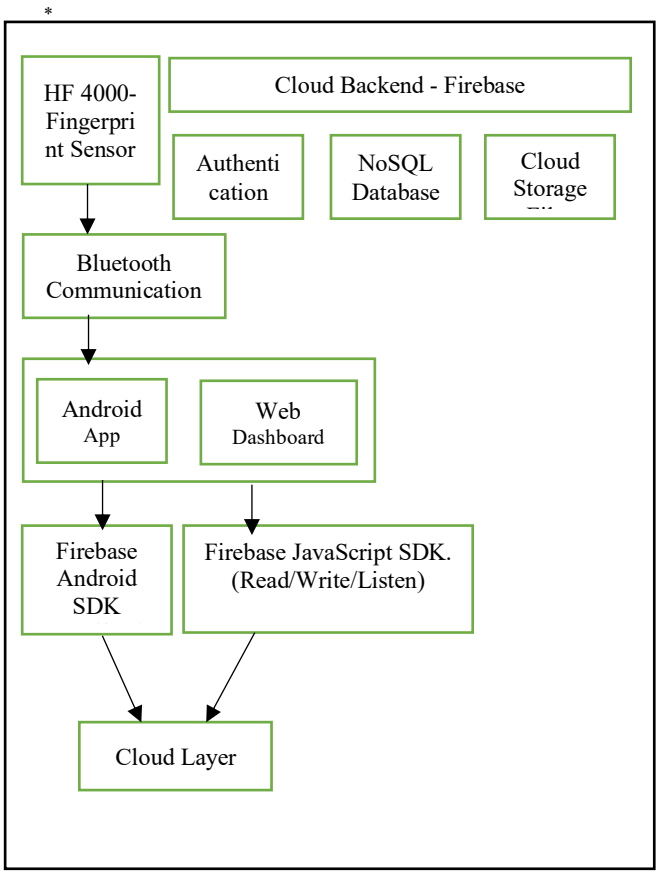

Fig. 2. High-level block diagram for the attendance system

In this research, UML diagrams were used to design the use case (Figure 3) for the attendance system, the flow of activities (Figure 4) and data (Figure 5) in the system, which defines how the users interact.

The important classes in the class diagram are:

- users: Stores lecturer profiles (name, email, role).
- departments: Contains department data and a unique invite code for lecturer access.
- classes: Contains class metadata (name, course code, year) and references its lecturerId and departmentId.
- students: Stores student details (name, matric number) with a reference to their classId.
- attendance: Documents each attendance session with classId, timestamp, and a sub-collection of records containing studentId and timestamp.

D. User Interface Design

The user interface design for the fingerprint biometric attendance system is to ensure that both the web-based dashboard and mobile application are intuitive, efficient, and accessible. The design process begins with wireframing, which involves creating sketches of the interface layout and structure without detailed visual design elements. Wireframes are developed using Figma, which is a collaborative design tool that facilitates rapid iteration and stakeholder feedback. Separate wireframes are created for the

dashboard and mobile application. The web dashboard interface is designed using a modular, card-based layout that organises information into sections.

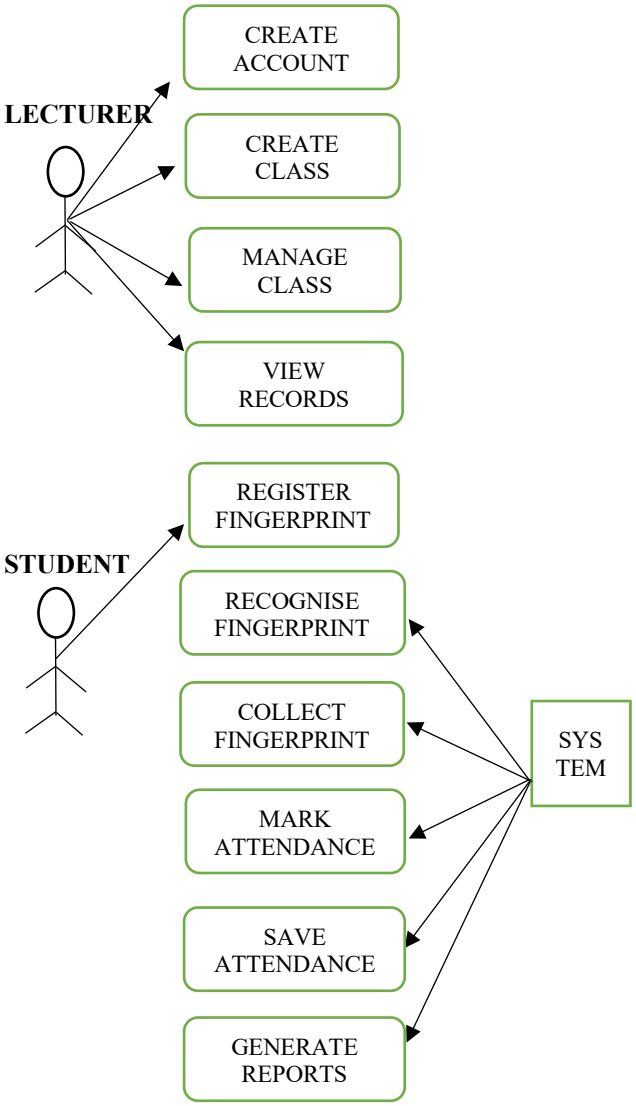

Fig. 3. The use case diagram for the attendance system

The design uses a responsive grid system that adapts to different screen sizes on desktop computers, laptops, and tablets. A navigation bar provides quick access to the main modules like Classes, Department, Attendance Sessions, and Reports. The forms for creating classes, adding students, and generating reports are designed with clear labels, input validation, and helpful error messages. Bulk upload functionality for student data is implemented with drag-and-drop file upload.

The mobile app design has the list of classes on the home page. Each of the classes has actions that allow the user to view the students in the class, enrol students, create new classes, and take attendance for a class. The enrollment page and the attendance page are where individual students add their fingerprints for enrollment and attendance. The wireframes are shown in Figure 6 and Figure 7.

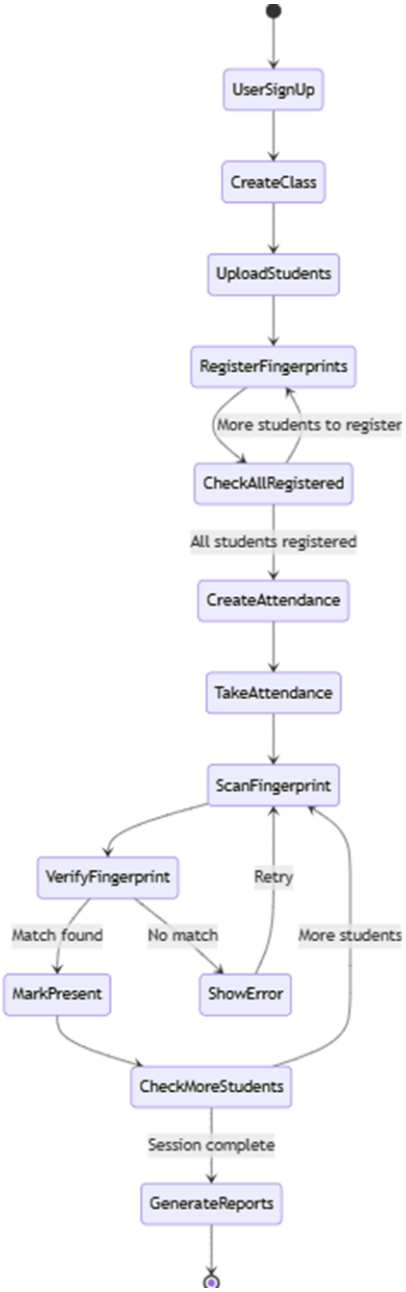

Fig. 4. The activity diagram for the attendance system

E. Biometric Performance Metrics

Two important metrics used in biometric system evaluation are the False Acceptance Rate (FAR) and the False Rejection Rate (FRR). The False Acceptance Rate is the probability that the system incorrectly accepts an unauthorised individual. This means it matches a fingerprint to the wrong person or accepts a fingerprint that is not enrolled in the system [13]. FAR is calculated using the formula below:

$$\text{FAR} = \frac{Number\ of\ False\ Acceptances}{Number\ of\ Impostor\ Attempts} * 100\%$$

where false acceptances are instances in which the system incorrectly identifies an unauthorised fingerprint as belonging to an enrolled student, and impostor attempts are

deliberate tests where enrolled students attempt to mark attendance using another student's identity.\

The False Rejection Rate is the probability that the system incorrectly rejects an authorised individual—that is, it fails to recognise a legitimate enrolled fingerprint [13]. FRR is calculated using the formula:

$$\text{FRR} = \frac{Number\ of\ False\ Rejections}{Number\ of\ Genuine\ Attempts} * 100\%$$

where false rejections are instances in which the system fails to recognise a correctly enrolled student's fingerprint, and genuine attempts are authentication attempts by students using their own enrolled fingerprints. A high FRR indicates that legitimate users frequently experience recognition failures, which would disrupt the attendance process and cause frustration.

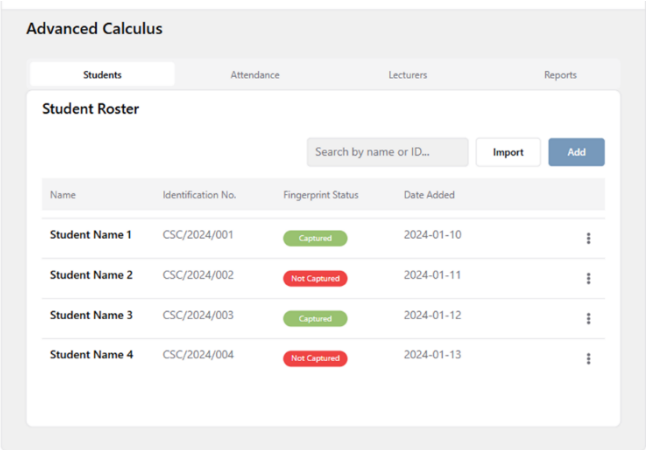

Fig. 6. Wireframe for the class management page on the web dashboard

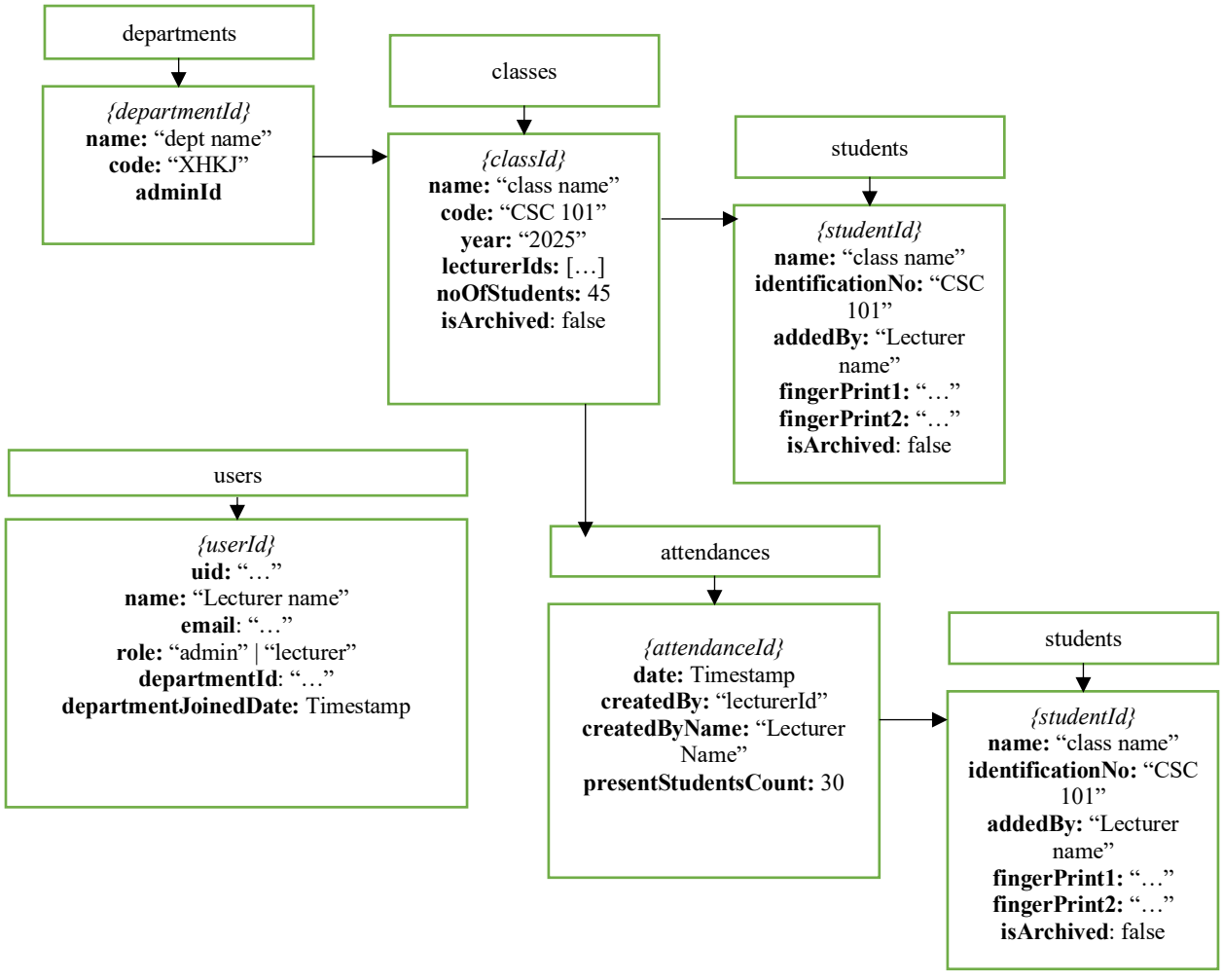

Fig. 5. The database structure for the attendance system

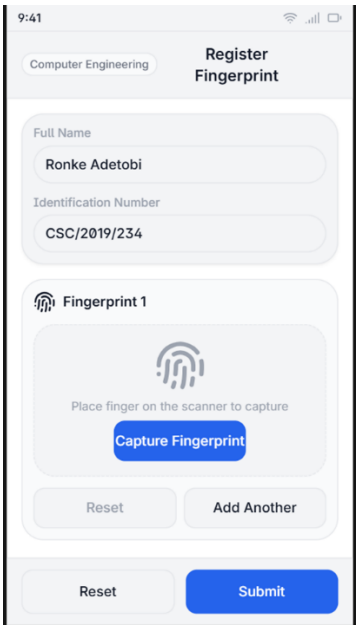

Fig. 7. Wireframe for the fingerprint registration page on the mobile app

IV. IMPLEMENTATION

1) Web Frontend Implementation: The attendance system web dashboard user interface is built utilising ShadCN User Interface (UI) components and styled with Tailwind Cascading Style Sheets (CSS). This approach allows for visual consistency and quick development. Complex features are broken down into self-contained, reusable components. The class detail page, as shown in Figure 8, is composed of several tabbed components, including the Students Tab, Attendance Tab, and the Reports Tab. Each of these tabs contains its own logic and state, from fetching its specific data to handling user interactions like adding a new student or generating a report. Dialogues and forms, such as the "Add Student" or "Import Students" modals, are also implemented as separate components, as seen in Figure 9. They manage their own form state using the react-hook-form library for validation and submission handling, making them easy to integrate and reuse across the application. The web frontend functionality implementation of the attendance system is done with Next.js React framework. The attendance system's real-time functionality uses *react-firebase-hooks* and direct Firebase Software Development Kit (SDK) calls within these hooks. The main dashboard uses an *useEffect* hook to establish a live connection to the Firestore database. This hook sets up an onSnapshot listener that queries for classes assigned to the logged-in user. Whenever a change occurs in the database, such as a new class being added or an existing one being archived. Firestore automatically pushes the updated data to the client. This new data is then set into the component's local state via useState, triggering a re-render and ensuring the UI always reflects the latest information without requiring a manual page refresh. The attendance system uses Firebase Authentication for sign-up and login, with dedicated pages for each (/login, /signup). Upon a successful login, the user is redirected to their main dashboard, as seen in Figure 10.

Client-side navigation is handled by Next.js's *useRouter* hook, which enables fast, single-page application (SPA)-like transitions between pages without full reloads. A centralised Header component displays user information and provides navigation controls, including a dropdown menu for accessing profile settings, department management, and the logout function. This component uses the *useAuthState* hook from react-firebase-hooks to stay subscribed to the user's authentication state, automatically re-rendering to show the correct UI whether the user is logged in or out. The attendance and reporting functionalities were implemented to be highly interactive, to provide lecturers with immediate feedback and administrative tools. These features are primarily housed within the ClassDetailPage (src/app/class/[id]/page.tsx), which uses a tabbed layout to separate concerns. The "Attendance" tab provides a real-time overview, as seen in Figure 11, and management of class sessions, while the "Reports" tab offers tools for generating and exporting PDF reports.

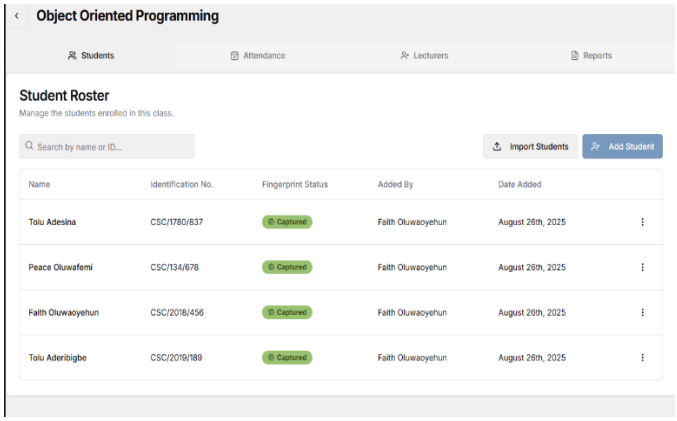

Fig. 8. Class detail web page for the attendance system

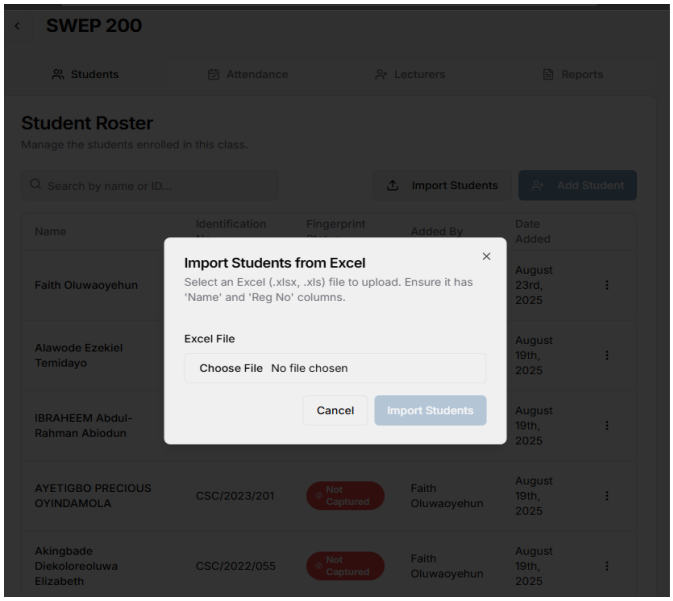

Fig. 9. Student management in the attendance system

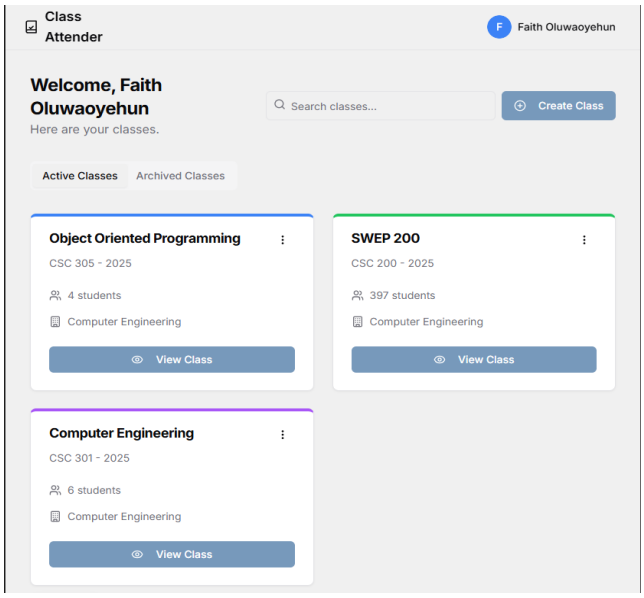

Fig. 10. Lecturer's dashboard after login

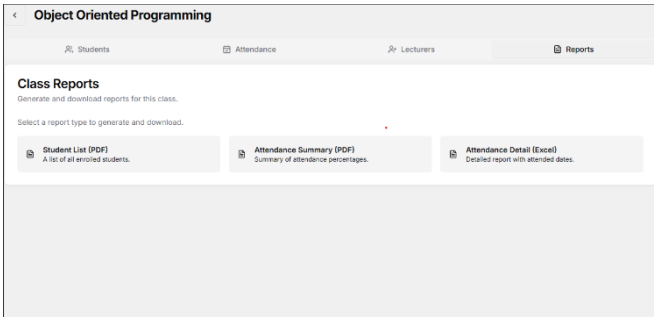

Fig. 11. Web page showing the attendance reports management.

2) Mobile Frontend Implementation: The attendance app uses the Model-View-ViewModel (MVVM) pattern, which separates the UI logic from the business logic. Each screen, or a group of related composable functions, is backed by a ViewModel. These ViewModels are responsible for fetching data from the repository layer, which communicates with Firestore and exposing it to the UI as observable streams of data, typically using Kotlin Flows or StateFlow. After successful login, the DashboardViewModel fetches the lecturer's assigned classes from Firestore. This data is collected as a StateFlow within the DashboardScreen composable. Jetpack Compose's *collectAsStateWithLifecycle* function is used to observe this flow in a lifecycle-aware manner, which means the UI automatically and efficiently re-renders to display the list of classes whenever it changes in the database, ensuring the lecturer always sees an up-to-date view without manual intervention. The application's most important features, which are fingerprint enrollment and attendance taking as seen in Figures 12 and 13, are implemented as state-driven workflows that manage the complexities of Bluetooth communication and data processing. When a lecturer initiates an action, such as tapping "Enrol Fingerprint" for a student, the UI navigate to a scanning screen. This screen is managed within the corresponding ViewModel, which handles the connection to the Bluetooth scanner via a dedicated service class. This class handles the low-level Bluetooth communication, emitting events for connection status, data reception, and errors. The ViewModel listens to these events and updates its UI state accordingly, causing the screen to display messages like "Connecting to scanner...", "Place your finger on the scanner," or "Scan successful." Once a fingerprint template is received, the ViewModel triggers a repository function to upload it to Firestore, linking it to the specific student's profile and checking for duplicates. This ensures that the UI remains responsive and provides constant feedback to the user, while the complex asynchronous tasks are handled cleanly in the background.

V. RESULTS AND DISCUSSION

The testing was conducted with 85 students to evaluate the system's ease of use, efficiency, and user satisfaction. The testing assessed multiple usability metrics, including completion rate, error rate, assistance requests, time efficiency and biometric performance. The results are documented in Figure 14 and explained below:

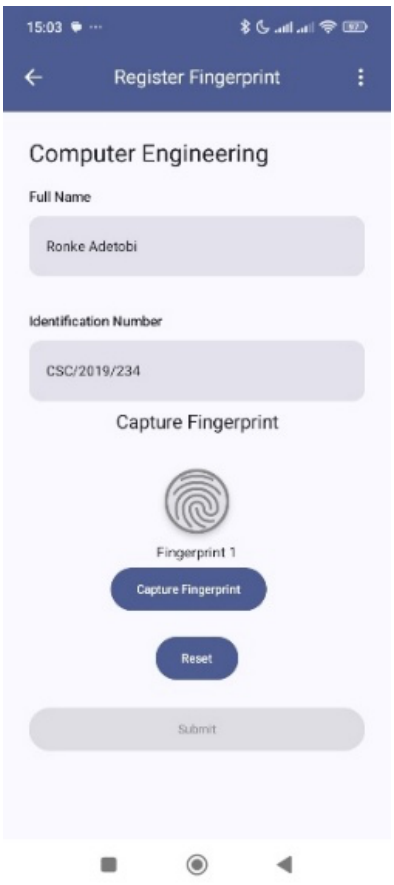

Fig. 12. Enrollment Interface for the attendance system

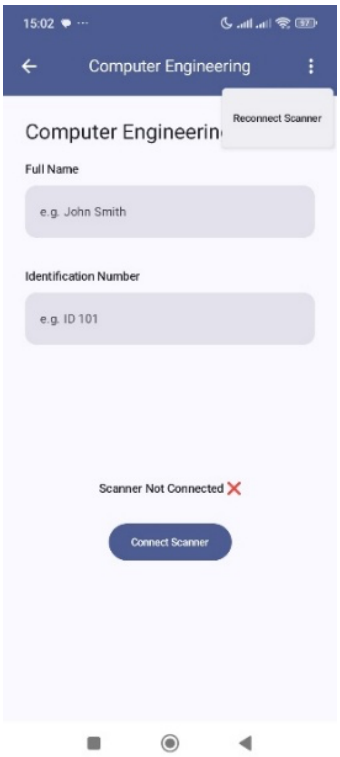

Fig. 13. An attendance capture interface for the attendance system

No.	Evaluation Metric	Result	Interpretation
1	Assistance Request Rate (Enrolment)	17.6% (15/85)	Primarily for finger placement guidance
2	Assistance Request Rate (Attendance)	4% (3-4/85)	Minimal help needed during operation
3	Average Enrolment Time	10 seconds/student	Single finger registration
4	Extended Enrolment Time	13-15 seconds/student	Two finger registrations
5	Average Attendance Marking Time	6 seconds/student	From scan to record creation
6	Total Class Attendance Time	8.5 minutes	For 85 students
7	False Acceptance Rate (FAR)	0% (0/50)	Perfect security against impersonation
8	False Rejection Rate (FRR) - Initial	17.6% (15/85)	Due to environmental factors
9	False Rejection Rate (FRR) - Operational	2-3%	After cleaning protocols implemented
10	Bluetooth Connection Time	<1 second	Quick scanner pairing

Fig. 14. Summary of System Evaluation Metrics and Results

i. **Completion Rate:** The fingerprint enrolment process achieved a 100% completion rate, with all 85 students successfully enrolling their fingerprints. However, 15 students (17.6%) required multiple attempts before successful enrolment. The initial failures were attributed to environmental factors, specifically, sweaty or oily fingers that reduced fingerprint image quality. After cleaning their hands and the scanner surface, these students completed enrolment on subsequent attempts. For attendance marking, the system demonstrated a high completion rate, with students able to mark their attendance successfully once their fingerprints were properly enrolled.

ii. **Error Rate:** The system recorded 15 initial enrolment failures out of 85 attempts, representing a 17.6% first-attempt error rate. However, these errors were not system malfunctions but rather environmental issues related to finger cleanliness and scanner surface contamination. After implementing proper cleaning procedures, all enrolments succeeded, resulting in a 0% persistent error rate. No application crashes, database connection failures, or other technical errors were observed during the evaluation period.

iii. **Assistance Requests:** Approximately 15 students (17.6%) requested assistance during the enrolment phase, primarily seeking guidance on proper finger placement and scanning technique. After brief instruction, these students were able to complete subsequent scans independently. During attendance marking sessions, assistance requests decreased significantly, with only 3-4 students (approximately 4%) requiring help, typically due to forgotten finger placement techniques or scanner connectivity issues.

iv. **Time Efficiency:** Enrolment time averaged 10 seconds per student, measured from student identification to successful fingerprint template storage. This duration includes the time for fingerprint capture (approximately 3-4 seconds), template creation and duplicate checking (approximately 3-4 seconds), and cloud upload (approximately 2-3 seconds). The system is capable of registering two fingerprints per student for redundancy, which extends the registration time to 13-15 seconds. Attendance marking averaged 6 seconds per student. This

includes fingerprint scanning (2-3 seconds), template matching (1-2 seconds), and attendance record creation with timestamp (1-2 seconds). For a class of 85 students, the total attendance marking time was approximately 8.5 minutes, which is significantly faster than traditional paper-based roll call methods.

The system's dependence on a specific external fingerprint scanner model (HF 4000 Plus) limits its compatibility with general-purpose or alternative biometric sensors. Also, the system is only available on Android devices and not iOS devices, as the scanner only works with Android devices.

VI. CONCLUSION

This project has shown the development and implementation of a portable, Bluetooth-enabled fingerprint biometric attendance system to achieve its aim of giving universities a secure, efficient, and flexible way to manage attendance. This project development followed the waterfall model. Requirement analysis, system design, implementation, and evaluation were all carried out. The system was tested with 85 students. Completion rate, error rate, assistance requests and time efficiency were used to assess the system.

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