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RESEARCH ARTICLE OPEN ACCESS

Design and Implementation of a Cloud-Based Attendance Management System Using Fingerprint Identification

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ABSTRACT: In this work, an electronic means of attendance collation using a cloud-based and fingerprint verification technology was designed and implemented. The system consists of three major subsystems: A hardware attendance capturing device (HACD), a locallyhosted server and a mobile application. The HACD comprises of the Power Module, HMI (Human Machine Interface) module, Wireless Connection Module and Fingerprint Identification Module. These four modules were all connected to an Arduino mega microcontroller which served as the brain of the HACD. The server subsystem utilizes a cloud-based server and database system to process and save attendance data collected from the fingerprint subsystem and makes it available to the mobile application on request. The mobile application was developed using Android Studio and Java programming language. The system was tested subsystem by subsystem to ensure all parts were working as designed and specified after which a complete and integrated test of the system was carried out from which results were obtained. The device was discovered to be fast as it took 4.5 S for the attendance of one student to be recorded and accurate in fingerprint identification as it recorded a true acceptance rate of 100%,a false rejection rate of 0% and a false acceptance rate of 0%. It was found to be reliable, secured and well-suited for classrooms attendance collation in Nigerian educational institutions.

Keywords – Attendance, Biometric Identification, CloudComputing, Fingerprint Verification, Wireless connectivity

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I. INTRODUCTION

It is a well-known fact that attendance to lectures is necessary and usually compulsory for students in academic institutions. In fact, the Nigerian Universities Commission

(NUC) stipulates that a student needs to attend at least 75% of the classes for a particular course for him/her to be eligible to write the exam [1]. The traditional and conventional system of taking attendance in Nigerian tertiary institutions is usually paper-based and manual, usually involving the lecturer passing round a sheet of paper for students to write their names and registration numbers or sign against their already printed names. This system poses a lot of problems and challenges as it is a cumbersome and time-wasting process. It is also very difficult for the lecturer to keep track of the students' attendance or generate statistical data from the already collected attendance data. This system also gives room for students to sign the attendance register for their friends and colleagues, thereby encouraging truancy and lateness. Over the years, various efforts have been made to automate the recording and management of students' attendance in tertiary institutions. This includes the design of devices using technologies such as facial recognition, fingerprint scanning, Radio Frequency Identification (RFID) tags, voice recognition, barcode scanning, etc. Each of these systems possess unique merits and demerits over the others but they all offer a digital means of recording and storing the students' attendance making it easy to access, process and manage the data effectively. Among the afore-mentioned techniques, fingerprint scanning has proven to be the most recognizable biometric modality around the world [2] [3]. This is due to its uniqueness, high reliability and speed. Fingerprint verification process is very fast, usually completed in a fraction of a second. It is not subjected to light intensity or other environmental conditions and can work perfectly in any condition. It also eliminates totally, the possibility of impersonation. With the advent of Internet of Things (IoT), a

technology that tends to connect devices and gadgets to the internet so they can effectively share datawithout requiring human-to-human or human-to-computer interaction [4], and cloud-computing, another new technology that enables the delivery of different services and resources over the internet [5]. Attendance management systems can be designed to process and store the data they acquire on an online server over the internet. This

then makes it possible to access the data from any part of the world with any device that can query the internet for it. With this innovation, a mobile or web-based application can be developed that will enable a lecturer access, view and analyze the students' attendance to his/her class anytime and anywhere. This project aims to develop a system that can be used to collate, track and analyze the attendance of students to lectures using fingerprint scanning technology.

II. LITERATURE REVIEW

The work in [6] proposes an Attendance Management System using Radio Frequency Identification. The system uses an ARM-7 LPC 2148 microcontroller, an oscillator circuit, preset circuit, LCD display and an RFID reader. The students are all provided with RFID-enabled ID cards which includes an inbuilt IC for storing and processing information. The system also uses a GSM module to send message to the parent if the student is present or not. Figure 1 represents the block diagram of the system showing its constituent parts and direction of data transfer.

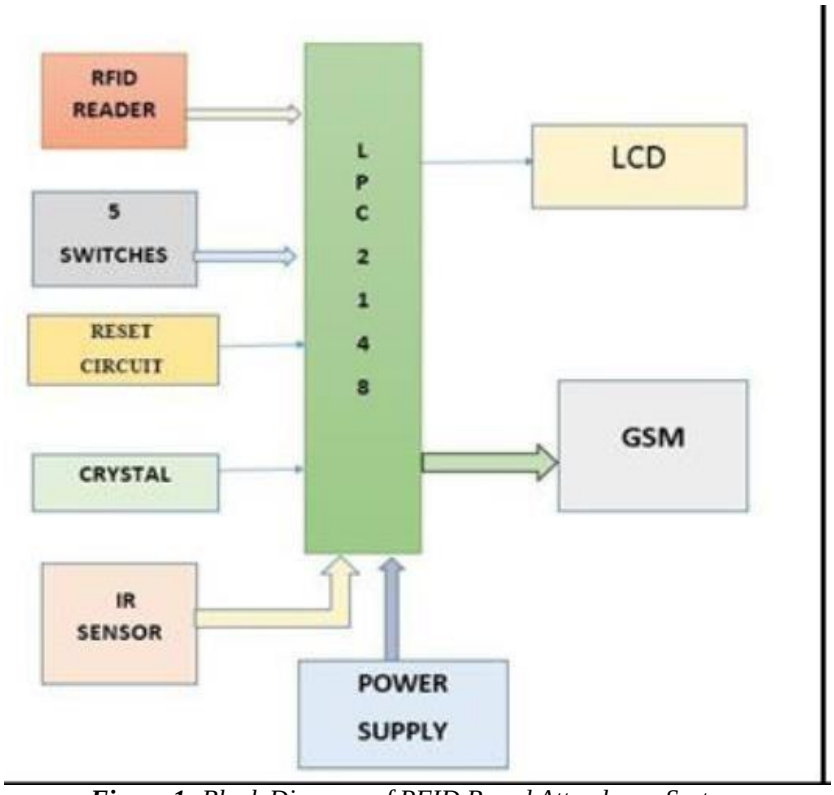

Figure 1: *Block Diagram of RFID Based Attendance System*

The paper in [7] describes a method where a snapshot is taken of a student when he enters the classroom and the attendance is marked by extracting and identifying the image using Personal Component Analysis (PCA) algorithm. The system will record the attendance of the student in class room environment automatically. The student database includes name of the students, their images and roll number. It maintains a log report entry of each student with respect to each subject and also generates a report of the student attendance. Using Simple Mail Transfer Protocol (SMTP) the report of the attendance information will be sent to the faculty and also to the parents. Figure 2 shows the flow chat for the capturing of attendance using the system

The paper in [8] proposes the application of the concept of Internet of Things (IoT) to the basic attendance system in a class room. A portable device was designed, where in every student could feed his/her attendance during each lecture. The student identification and verification were done using R-305 Finger Print module. Once successful recognition of finger print pattern was done, the student's attendance, comprising of the student ID, teacher ID and device ID (i.e. a unique no. of the hardware) was pushed to the web-server using Wi-Fi Module esp8266-01. A PHP script did the subsequent work, to

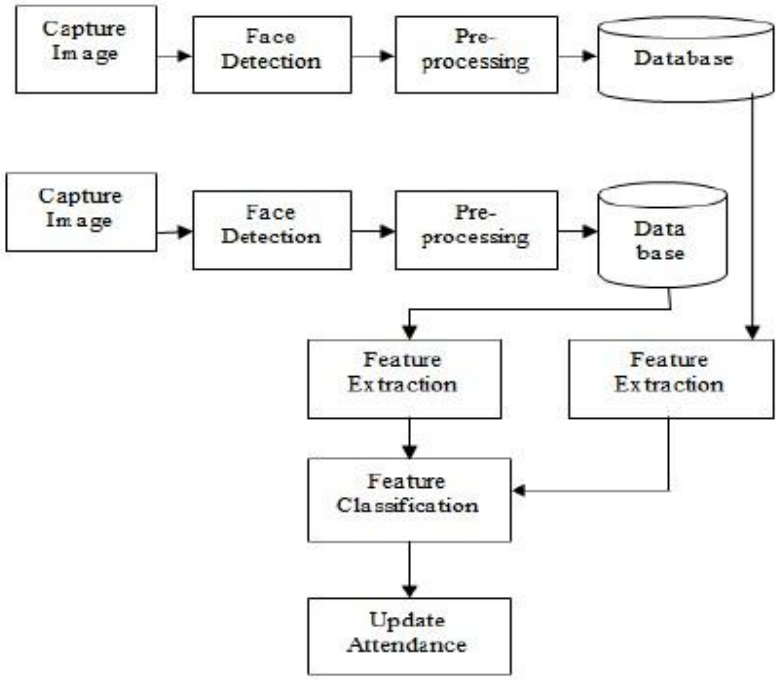

Figure 2: *Block Diagram of Automated Class Attendance System Based On Face Recognition Using PCA*

*Algorithm*interpret the data, and the MySQL database was updated. Data from the database was retrieved and sent to the website for easy viewing by the student. The whole system was implemented on a dedicated web-server. The block diagram of the IoT Based Attendance System is as shown in figure 3.

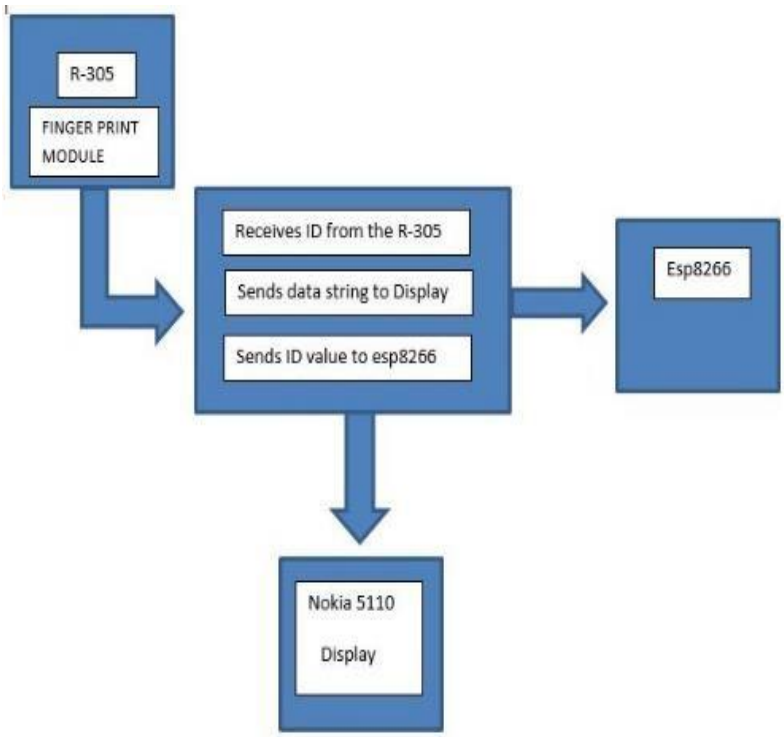

Figure 3: *Block Diagram of Implementation of IoT Based Attendance System on a Dedicated Web-Server*

Each of the systems above possessed its own unique challenges. None of the systems included a robust Real-Time Operating System (RTOS) that could allow the system be used for the multiple courses usually offered by a student in a particular department. These systems were also not designed to provide the percentage of classes a student attended or determine if the student was eligible to sit for an examination. Also, with the increase in the use of smart phones, it is necessary to provide an easy-to-use mobile application that will allow lecturers access class attendance at a glance at any given time.

III. SYSTEM DESIGN

The Cloud-based Attendance Management System with fingerprint identification provides a centralized and electronic system for the collation, analysis and management of student's lecture attendance in any department. It provides detailed analysis of the student's attendance in each course, clearly showing the students percentage attendance. The project comprises three subsystems: *A.Server subsystem:*

The project utilizes a cloud-based server and database system to process and save attendance data collected from the fingerprint subsystem and makes it available to the mobile application on request.

B. Attendance Capturing Device:

The Attendance Capturing Device is designed with an Arduino Mega microcontroller board interfaced with a fingerprint module and other electronic component. The subsystem allows fingerprint of students to be enrolled during registration and attendance collected by fingerprint matching during lectures.

C. Mobile Application subsystem:

The android application serves as the interface between the lecturers and the attendance management system. It allows lecturers to view the cumulative attendance data of students in the various courses they handle and the list of students that attended a lecture on any particular day. This subsystem also provides an interface for the registration of students and lecturers and the allocation of courses to lecturers.

The system first allows profiles of students and lecturers to be created using the mobile application from the admin account which is then stored in the cloud database. The database was designed using MongoDB, a NoSQL database that allows data to be saved as JavaScript objects. Student's fingerprint patterns are also enrolled using the fingerprint module and are matched to their registration numbers. The attendance is taken when students fingerprint patterns are matched with the pre-enrolled patterns and the associated registration numbers posted to the cloud-server together with the timestamp of recording the attendance which are saved in the database. The mobile application allows lecturers view the cumulative attendance of the various students taking their course and the attendance list for any particular day.

IV. HARDWARE IMPLEMENTATION

The hardware Attendance Capturing Device comprises the following four modules:

A. Power Module
B. HMI (Human Machine Interface) module
C. Wireless Connection Module
D. Fingerprint Identification Module

These four modules were all connected to an Arduino mega microcontroller which served as the brain of the hardware attendance capturing device. A Real Time Operating System (RTOS) was developed and uploaded to the microcontroller which helped to control the activities of the four different modules, ensuring they perform as efficiently as was designed. The RTOS also used an RTC (Real Time Clock) module to provide synchronization amongst the various other modules and determine the time of attendance submission.

The Power module consists of rechargeable Lithium-Ion cells and associated electronic circuitry that assists in the charging of the cells. The power module supplies 5V dc power to all other components of the ACD.

The HMI module consists of a 4*4 numeric keypad and a 16*2 LCD display fitted with an I2C adapter. The HMI module provides the means by which the user can interact with the ACD while navigating the various options available, making course selections or inputting registration numbers. The 8 pins of the keypad were connected to the digital pins of the Arduino while the I2C data pins (SCL and SDK) of the LCD display were connected to the corresponding pins on the microcontroller.

The wireless connection module consists of an ESP8266 Wi-Fi module connected to the Arduino microcontroller. The Wi-Fi module enables the ACD connect to an internet-enabled network thereby permitting it to upload the attendance data collected to the cloud.

The Fingerprint Identification module consists of a fingerprint scanner connected to the microcontroller. This is the most important module in the ACD as it is used for the enrolment of fingerprints and the identification of students while taking attendance.

All the modules and components were housed in a plastic box to ensure ruggedness and durability.

V. SOFTWARE IMPLEMENTATION

Three different software were developed to run the Attendance Management System.

A. A Real-Time Operating System for the Attendance Capturing Device

B. A server-side application that serves as the interface between the ACD and the mobile application.

C. A Mobile Application used by lecturers to access the attendance information.

The RTOS was written using the Embedded C language for Arduino Microcontrollers. Libraries were included in the program in order to make use of the components in the HACD.

Http requests were made by the program in order to post attendance data.

When turned on, the ACD first checks to ensure all peripheral components are connected. Then the user can either choose to enrol a new student or take attendance. If the user selects to take attendance, he has to navigate using the navigation buttons and selects the course. The device is then passed round to identify the fingerprints of the members of the class present. After everyone has been recorded, the lecturer has to end the attendance collection by inputting a unique pin and the attendance data will be uploaded to the server.

Figure 4 shows the flowchart of operation of the HACD while taking attendance.

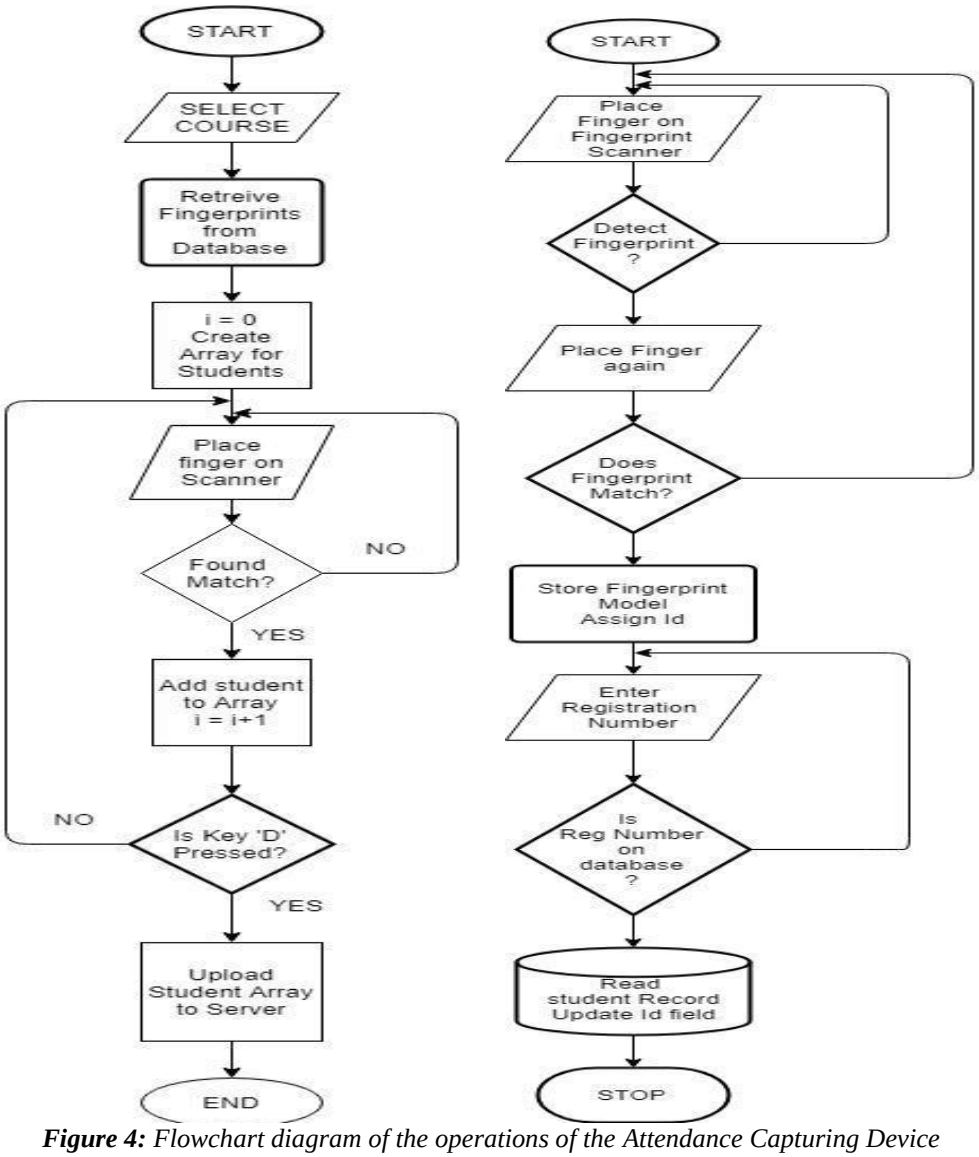

Figure 4: *Flowchart diagram of the operations of the Attendance Capturing Device*

Figure 5: *Flowchart diagram showing the fingerprint* Figure 5 shows the flowchart of the student's biometric *enrolment process* enrolment process.

The server-side application was developed using Node JS and MongoDb database. Several APIs were developed that allowed both the mobile application and the HACD get/post data from the server respectively.

Students and lecturers can be enrolled using the mobile application and the data filled is stored on the server. After the attendance data has been uploaded from the ACD, it is saved in the Attendance table on the server while the NoClassesHeld and LastClassHeld fields of the Course table are updated.

The mobile application was developed using Android Studio and Java programming language. It enables a lecturer view either the cumulative class attendance for a particular course or the list of students present in a particular date. It also shows the attendance summary of a student in all his registered courses which can be sent to the mail of the student's parent. The mobile application is also used to add new students, lecturers and courses. The Volley library was used to enable these mobile app make http calls on the server.
Figure 6 shows the dashboard of the mobile application.

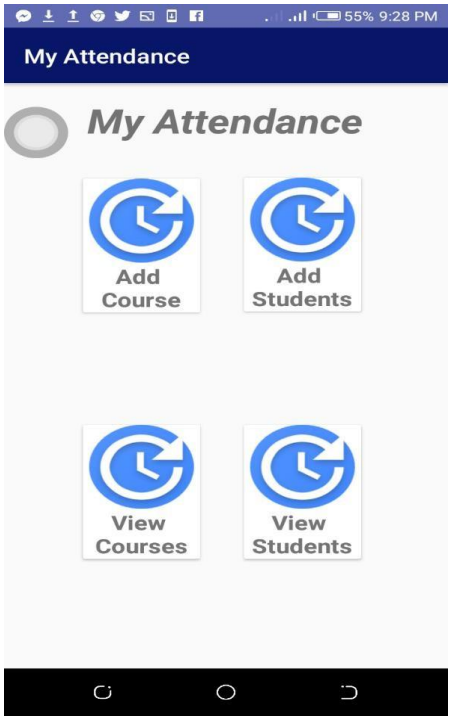

Figure 6: *Dashboard of the mobile application*

Figure 7 shows the list of courses undertaken by a lecturer.

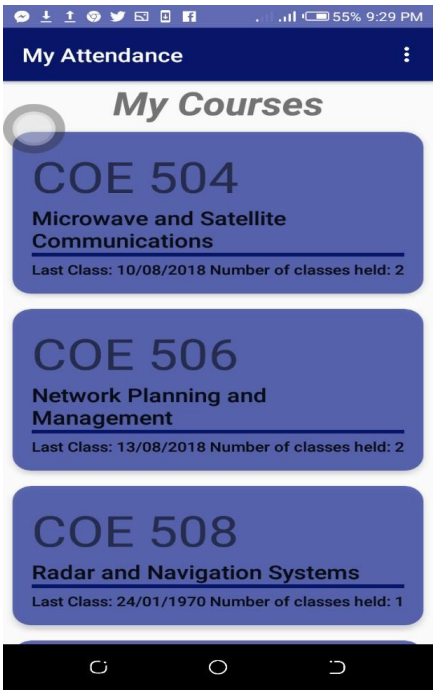

Figure 7: *Activity on the mobile app showing the list of courses undertaken by a lecturer.*

VI. TESTING AND RESULTS

After the Attendance Management System was fully developed, the system was tested sub-system by sub-system before a complete integrated test was finally carried out.

A. Testing of the Server: The various API calls developed in the server and the MongoDb database were first tested using a software called POSTMAN. Several http requests were made through routes and addresses already developed on the server.

B. Testing of the mobile application: The mobile application was tested manually to ensure that all activities and user interface components performed as expected.

C. Testing the Attendance Capturing Device: The attendance capturing device was built using an incremental model where all the components were all individually interfaced to the microcontroller and tested in order to set them up and ensure they were working. After they were all interfaced correctly to the microcontroller and the complete code uploaded, the system was tested again to ensure it successfully uploaded attendance data to the server.

D. Integrated Testing of the System: First, the mobile application and attendance capturing device were turned on and they connected to the locally-hosted server using Wireless Network. Ten students were registered using the mobile application. With the attendance capturing device, their fingerprints

were enrolled and the student records on the database updated.
5 demo attendance was taken by the enrolled students randomly and with the mobile app, the cumulative attendance was displayed in percentages for the various courses. The results got and attendance recorded are as shown in figure 8.

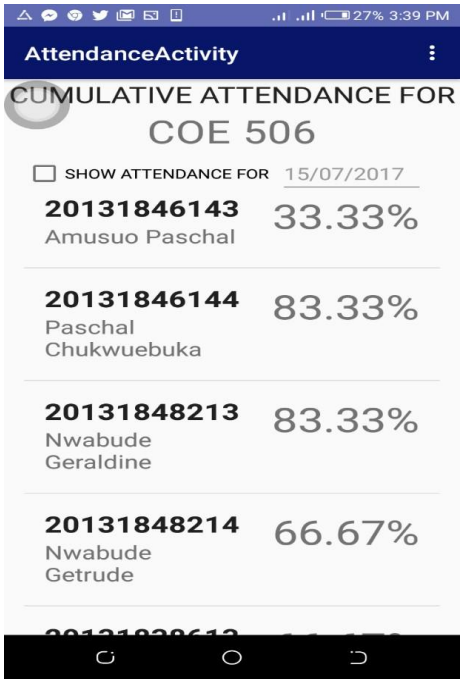

Figure 8: *User Interface of the Mobile Application*

B. Accuracy:

This is a measure of how well the biometric system is able to correctly match the biometric information from the same person and avoid false matching biometric information from different people. In this project, the fingerprint scanner correctly matched the fingerprint patterns of the students enrolled for the test. This gave a True Acceptance Rate of 100%.
Also, the system didn't record any case of false rejection, giving a false rejection rate of 0%.
The system also rejected all non-enrolled fingerprints giving a False Acceptace Rate of 0%.

C. Reliability:

Given the accuracy analysis above, we discovered our attendance system was highly reliable and could be deployed to classroom for attendance purposes without fear of it rejecting a student's attendance or false recording attendance for an absent student. *D.Security:*

Our attendance system was designed to have good security measures to prevent unauthorized users from accessing or manipulating the data on the database. Lecturer's password was encrypted and the lecturer had to log in before he could assess the application. Also, the server codes, when finally uploaded to the internet, will be properly encrypted against hacking and other online vices.

VII. DISCUSSIONS

The result generated during the test run of the Attendance Management System can be discussed in terms of the Speed of operation, Accuracy, Reliability and Security.

A. Speed of Operation:

First, we recorded the time it takes from when the finger was placed on the fingerprint scanner to when it displayed
"Attendance Recorded" on the LCD display. It took approximately 1.25 seconds. In the test run, the attendance of ten students seated in a classroom were captured by passing the attendance capturing device round the class. It took approximately 45 seconds for the attendance of the ten students to be captured and recorded. By this analysis, it means that it takes approximately 45/10 = 4.5 seconds for the attendance of one student to be recorded. Hence, for a class of 100 students, it would take approximately 4.5 * 100 = 450 seconds which is approximately equal to 7.5 minutes.

VIII. CONCLUSION

The need for a robust, centralized and secured attendance management system led to the idea behind the development of this project. The manual means of collecting and collating attendance is usually tedious and time-wasting and results in a lot of errors and inefficiencies, sometimes leading to the omission of a student's name or transfer of attendance to another student. This centralized attendance management system with fingerprint identification alleviates the numerous problems associated with the manual attendance system by providing a means by which student's class attendance can be collected and stored electronically while preventing students from taking attendance for the peers. The system consists of three major subsystems which include the hardware attendance capturing device, the server and the mobile app used for accessing the

attendance data. The system is secured and reliable, has fast response time and is well designed and suited to the various conditions of a Nigerian university classroom. It also provides a summary of student's attendance in a course in a semester in percentage to enable lecturers properly grade their students.

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