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A SMART REAL-TIME ATTENDANCE SYSTEM USING SMART DATA FILTERING AND SELECTION TECHNIQUES

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Abstract

Cooperate organizations, firms, companies, and educational institutions in Nigeria and the whole world are concerned about attendance of students and employees as the case may be, student overall performance is affected by it. In order to provide solutions for attendance management systems, a variety of techniques and technologies were used in the development of the attendance systems. However, most of these systems lack the flexibility of use and appropriate resource management. This paper presents the development of a smart real-time attendance system that uses smart data filtering and selection techniques to parse user-defined attendance instructions, optimize performance, and improve efficiency and flexibility. This system also employs a multi-factor approach in terms of security engaging the use of RFID technology and fingerprint biometrics to manage attendance records. Also, the system uses a wireless (Wi-Fi) communication approach for real-time communication. The performance of the system was mainly evaluated in terms of throughput, latency, and accuracy showing an average delay of 3 seconds per student, 21.95Mbps average throughput, and zero percent false acceptance.

Keywords - Wi-Fi communication; smart data selection; User-defined attendance instruction; RFID; Fingerprint Biometrics

1.0 Introduction

Attendance is used for several purposes in educational institutions, cooperate organization and firms. Which includes student's assessment, staff assessment and record keeping [1]. Attendance management is the act of managing attendance or presence in a school or work setting to minimize loss due to student-employee downtime [2]. The academic performance of students is tremendously affected by it so there is an urgent need for the development of better attendance management systems. The most common means of tracking student attendance in the classroom is by enforcing the students to manually sign the attendance sheet, which is normally passed around the classroom while the lecturer is conducting the lecture. Such a commonly managed system is inefficient and lacks automation [3].

RFID technology which stands for Radio Frequency Identification are devices used in transmitting and receiving data wirelessly over an electromagnetic field [4]. This technology are most times used for authentication. An RFID system consists of a reader and a tag. RFID readers sends commands to the RFID tags which in turn responds based on commands received. Active tags are self-powered tags while passive tags receive power from the RFID reader. The use of RFID based attendance system enables students or employees to get attendance recorded by placing their unique RFID tags over the RFID reader, but this poses a problem of impersonation as friends and colleges of students can granted use of their RFID tags without being present.

Therefore, using Fingerprint technology along with the RFID technology would help to solve critical issues like identity theft. Fingerprint technology recognizes a unique human characteristic called fingerprint as it has been empirically proven over the years that no two human beings have the same fingerprint [5]. Hence this will be used in the developed attendance system to make it full proof. Biometric technologies have been employed in fields of human identification and verification. These technologies make use of different methods and approaches in analyzing the biological features that is presented in the human body and discovering various unique patterns which can be used for identification. One of the most recently developed biometric recognition system uses heart rate variability in humans. Other biometric feature used include; fingerprint, palm vein network, iris, voice and facial features. The fingerprint feature is still most widely used biometric technology due to its success ratio compared to other biometric systems.

In term of communication, the use of wired technology like data cables are usually discouraged as it lacks flexibility of use. Wireless Technology are now often being used for most system's communication interface. Wireless LAN (Wi-Fi) technology was designed originally to replace wired network systems [6]. It was used in the presented system for communication and transfer of attendance data.

An intelligent real-time attendance system is developed and presented in this study using smart data filtering and selection technique with a multi-factor authentication module.

The rest of the paper is structured as follows. Section 2 presents some of the related literatures in the field of study. While, Sections 3 presents the system design and implementation. Section 4 presents the system evaluation, while conclusion and recommendation for future work is presented lastly in section 6.

2.0 Related Works

The application of various techniques and technologies for establishing attendance systems is utilized to offer solutions to issues in attendance management, according to reports presented by various practitioners and academicians.

The System proposed in [7] Uses Wireless Technology. The report suggests the use of RFID and Facial recognition-based attendance where the facial details and RFID tags assigned to each of its users are recorded for authentication and transferred to an authorized administrator via WhatsApp. The advantage of this kind of system is that it has a two-way authentication system making it fool proof to some extent with a major drawback of time consumption during attendance validation.

In [8], a barcode-based student attendance system was developed. One major advantage of the system is that it's a cost-effective system that only requires one hardware component which is the barcode scanner. The barcode scanner scans through the student ID card containing a Barcode. Though the system generates and prints out an attendance report but does out check against impersonation common with cards.

A resource optimization solution based on Template-Free Fingerprint Biometric Key Generation using Fuzzy Genetic Clustering which generates keys from statistical features of biometric data rather than the generation of

Fingerprint templates was proposed in [9] and then implemented in [1].

In the same vein, [10] developed a digital punch card-like attendance system with better capacity and improved features where students log attendance through their smartphones wirelessly using Bluetooth technology. The System's Attendance Device was developed with Raspberry Pi. It searches through the available Bluetooth devices to verify and validate attendance. The system has a constraint of limited storage capacity.

Furthermore, [11] cited the use of an attendance system that uses facial recognition and a Raspberry Pi system controller and pi camera as the input device. The facial recognition uses Local Binary Pattern algorithm which is less affected by external environment. Although factors like user's age, the lighting of the environment, glasses worn by users, along with head and face covers all impact false reject rates.

Similarly, [12] also developed a facial recognition-based attendance system using a different approach. The approach employed for development involved the use of Deep Learning and Artificial Neural Network (ANN). The convolutional Neural Network model was the ANN model used for the recognition. These ANN algorithms require a lot of processing power. Thereby it's a resource-demanding technique.

The solution to provide a much more reduced and simplified data set for performing real-time analysis was proposed in [13]. Smart data selection techniques were used to determine and select the currently required data for real-time use rather than querying the entire data set.

The study in [14] goes beyond attendance management to look into factors impacting pupils' academic achievement. Contrary to popular belief, the findings show that attendance is not the key predictor of academic performance. Extra educational support, participation in extracurricular activities, and strong family support were found to be the most influential determinants of academic performance. This nuanced view of the multifaceted nature of academic success challenges conventional wisdom and emphasizes the significance of a comprehensive approach to student well-being.

A biometric attendance system determines an individual's presence by documenting instances of entry and exit. These systems are widely utilized and supported due to their promising results in attendance management [15]. This strategy mitigates the risk of proxy attendance by reducing time differences, which can hurt an organization's overall efficiency. Biometric systems are frequently linked to multiple platforms to interpret collected data into meaningful outcomes. Fingerprints, voice patterns, hand size, iris scans, and other features are used by biometric systems to identify and validate individual traits.

Therefore, to overcome the shortcomings of the previously discussed system, we propose a smart real-time attendance system using smart data selection and filtering techniques to parse user-defined attendance instructions, optimize performance, and employ a multifactor (RFID and Fingerprint technology) authentication system. To achieve this, we are making use of a standalone attendance management software to store attendance records in real-time while communicating with an attendance device over a Wireless LAN (Wi-Fi) Network.

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3.0 System Design

The proposed system introduces the use of smart data selection and filtering techniques which determines what live data is of interest for real-time analysis. It also employs the multifactor authentication approach suggested in [1] where RFID cards which store a Unique ID for each student and fingerprint biometrics are both used to ensure a more layered security protocol. The system implementation is of two categories; software implementation and hardware implementation. The software implementation led to the development of attendance management software, while the hardware implementation led to the development of an attendance device.

The attendance device is made up a single board microcomputer called raspberry pi which serves as the central control unit integrated with fingerprint sensor, RFID sensor, 3.5inch TFT LCD touch screen, buzzer and LED. Raspberry pi boards are of different classes and types. The Raspberry pi chosen for the proposed system is of class 3 model B which has an inbuilt Wi-Fi clip making it a perfect choice of use for developing wireless communication systems. The Fingerprint sensor captures the fingerprint image, RFID sensor responds to an RFID tag within a specific range by creating an electromagnetic field used to power the RFID tag and receives data from it, the 3.5inch TFT LCD touch screen is used to provide an output display, and receive user input, while the buzzer provides output in form of sound. Figure 1 shows the block diagram of the system hardware. The attendance management software is used for storing student biometric and academic information, attendance data, generating user-defined attendance instruction, and for generating SMS and documented reports.

The design of the smart real-time attendance system is made up of the following:

a. Registration Module
b. Authentication Module
c. Attendance Management Software.

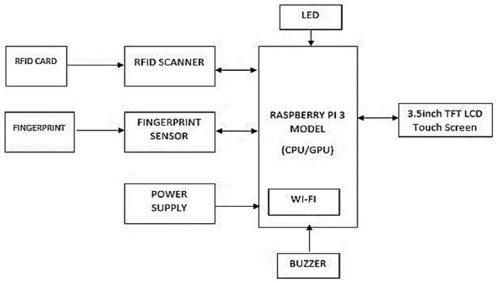

Fig 1. Block diagram of the system hardware.

3.1 Registration Module

The Task of the Registration Module is to enrol a user or student into the system storing his biometric record and other required information like, name, department, mobile number, parent number in the system's database.

During registration, the raspberry pi in the attendance device triggers the fingerprint sensor to capture fingerprint biometrics of students extracting the miniature data and other statistical features used for generating the biometric key. The captured data is then transferred wirelessly via a Wireless LAN (Wi-Fi) Network to the attendance management software. Other information like Student ID, matriculation, and department is entered directly into the system through the attendance management software.

The registration process is carried out by the authorized personnel or administrator. Other student information like name, matriculation number, and department are also stored in the

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database. Figure 2 shows the block diagram of the registration module.

3.2 Authentication Module

The Authentication perform the task of validating the identity of a person that intends to access the system. Both RFID and the Fingerprint sensor are used for this process. Figure 3 Shows the block diagram of the authentication module.

Before the Authentication process can take place, the administrator is required to define an attendance instruction that will be used to configure the attendance device. Attendance instruction is embodied in an Attendance Instruction and Fingerprint Data (AIFD) file. The user-defined attendance instruction is contained in the JSON-type configuration file known as the AIFD file and smartly selected fingerprint data. This fingerprint data is the live data of interest for the real-time attendance process. The AIFD file is sent from the attendance management software to the attendance device.

Once the attendance device receives the AIFD file it initializes and stores the fingerprint data into the attendance device. Once the fingerprint data is successfully stored into the attendance device the attendance device begins to operate. The student ID stored in RFID tags and biometrics of students are compared with the data stored in the database for a match and if the match is found the attendance device sends the record wirelessly to the attendance management software in real time.

3.3 Attendance Management Software

An embedded database is a component of the attendance management software. The embedded Database Management System (DBMS) differs from server-based DBMS in that it operates independently of an active web server; rather, it activates upon programme activation. Additionally, the logic and control tasks involved in various approaches of processing data obtained from the registration and authentication module are managed by the attendance management software. Data that is temporarily saved in the authentication module's memory is sent by the attendance management programme. The temporary storage database holds the real-time (usable) data for the ongoing attendance, this data includes the fingerprint data, RFID information as well as additional helpful student data. All of the student records and attendance reports are stored in the software's database on a separate PC that has been given permission by the lecturer. Parents of students receive occasional SMS notifications from the attendance management software. Lastly, a defaulters list, or table comprising a list of students or attendees who did not meet the NUC 70% attendance rate benchmark, is created by the Attendance Management Software after running queries over the attendancerecord.

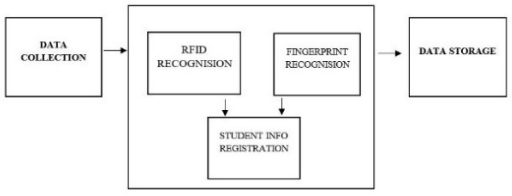

Fig 2. Block diagram of Registration Module

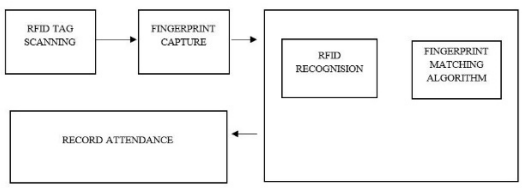

Fig 3. Block diagram of Authentication module.

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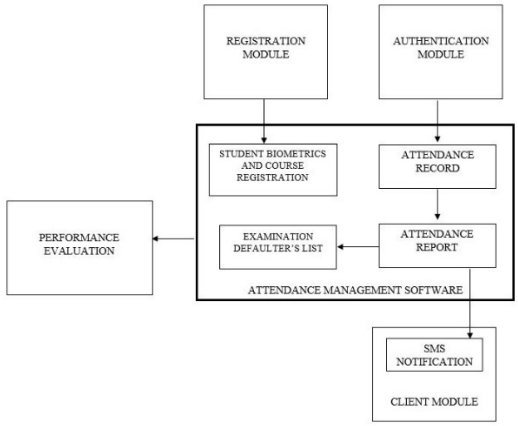

Fig 4. Block diagram of the Overall System

The Figure 5 shows the data flow diagram AIFD file generation process using smart data selection and filtering technique. As the administrator provides an attendance instruction consisting of attendance event, timing instruction and expected attendance size, the distinctive properties of the attendance event are used to generate an SQL query command which is then used to query the database selecting Fingerprint data that matches the expected attendance size and attendance event. Only fingerprint data particularly needed for the attendance is stored in the AIFD file. Using this technique helps to reduce the issue of memory constraints by filtering out unnecessary data and also helps to increase the efficiency of the fingerprint sensor by reducing the search space during one-to-many matching.

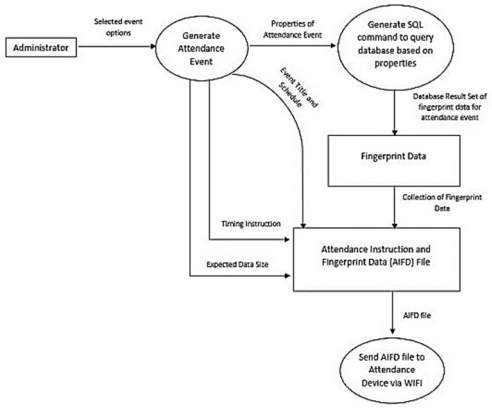

Fig 5. Data Flow diagram of AIFD file generation using a Smart data selection and filtering technique.

Therefore, using smart data selection and filtering techniques ensures that only the data required is used for the attendance process. Some data stored in the fingerprint and attendance device during the attendance process are wiped out after the attendance process has been completed.

3.4 System Implementation

The system components of the attendance device include, Raspberry Pi 3 model B, 3.5inch TFT LCD Touch Screen, 13.56MHz RFID reader, ZFM-20 Fingerprint Sensor, LED, and Buzzer. The components were tested and integrated procedurally into the system. The attendance device plays the role of both the registration and authentication module. The attendance device incorporates functions of sensing, actuation, and control, and takes decisions based on available data or instructions provided by the administration. Figure 6 shows the developed attendance device.

Fig 6. Attendance Device.

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3.5 Software interfaces

3.5.1 Registration Interface

This interface is categorized into three; student registration, administrator registration and course registration. The administrator registration interface is the first window that is displayed during the first launch of the software.

3.5.2 Login interface

This is platform is provided to verify that the user attempting to use the system is an authorized user (administrator). Figure 7. Shows the login interface.

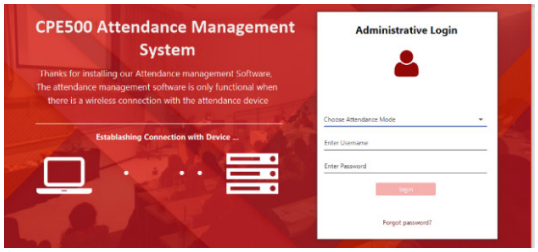

Fig 7. Login Interface

Below is a Figure showing the student Fingerprint biometric registration process. Here the fingerprint received from the attendance device is attached to a student selected by the administrator.

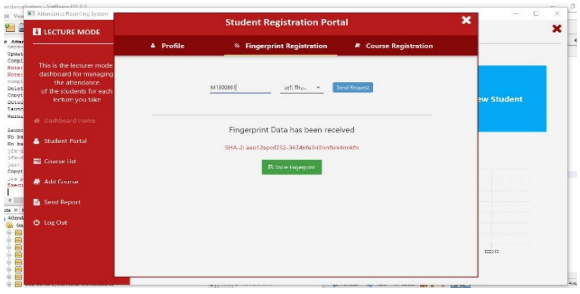

Fig 8. Student Fingerprint Registration interface.

3.5.3 Attendance Initialization interface

The Interface in shown in Figure 9. Provides the administrator with a platform for setting and defining the attendance instruction used to configure and start up the attendance device authentication process.

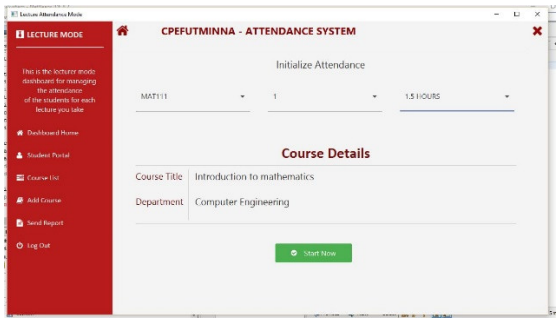

Fig 9. Attendance initialization interface.

3.5.4 Live Attendance record interface

During the attendance recording, the attendance device sends attendance record wirelessly over a Wi-Fi network and the attendance software recieves it in real-time. After Live Record ends, the interface presents an option to save attendance report in PDF/Excel format or to print. See Figure 10.

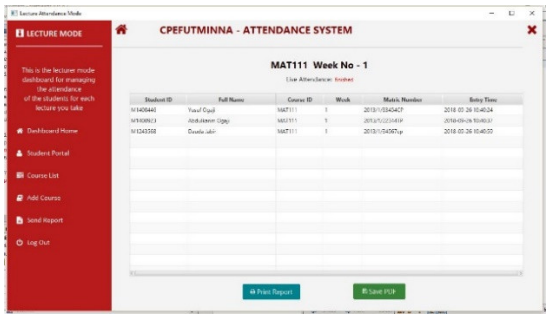

Fig 10. Live Attendance Recording.

3.5.5 Attendance Report Generation

The Attendance report generated is of two types; the Lecture attendance report and the examination defaulters list. The attendance report generated is saved as an Excel document. The fields of lecture attendance report spreadsheet as shown in Figure 11 includes; the student ID, student's name, course code of the lecture taken, her/her matriculation number and entry time. The generated report is compiled for every student and used for sending SMS report to student's

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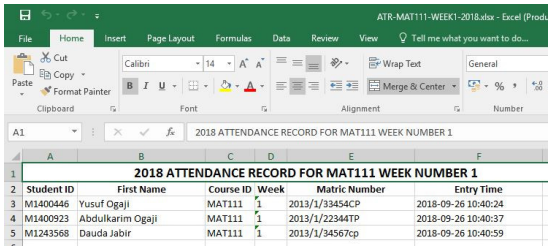
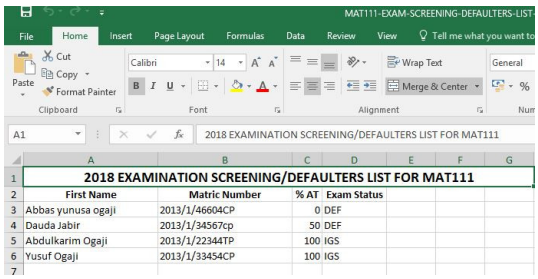
parents or guardian as shown in Figure 13. While the report shown in Figure 12. Is known as the Examination Screening/Defaulters list. This report is generated per course after the final lecture week before examination commences. This report was developed in the hope of implementing the NUC 70% attendance policy therefore any student that does not make the minimum of 70% attendance will be prevented from seating for the examination.



2018 ATTENDANCE RECORD FOR MAT111 WEEK NUMBER 1

Student ID	First Name	Course ID	Week	Matric Number	Entry Time
M1400446	Yusuf Ogaji	MAT111	1	2013/1/33454CP	2018-09-26 10:40:24
M1400923	Abdulkarim Ogaji	MAT111	1	2013/1/22344TP	2018-09-26 10:40:37
M1243568	Dauda Jabir	MAT111	1	2013/1/34567cp	2018-09-26 10:40:59

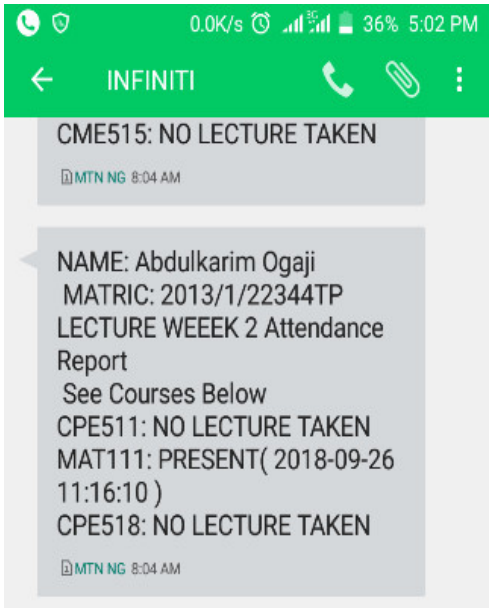
Fig 11. Lecture Attendance Report



2018 EXAMINATION SCREENING/DEFAULTERS LIST FOR MAT111

First Name	Matric Number	% AT	Exam Status
Abbas yunusa ogaji	2013/1/46604CP	0	DEF
Dauda Jabir	2013/1/34567cp	50	DEF
Abdulkarim Ogaji	2013/1/22344TP	100	IGS
Yusuf Ogaji	2013/1/33454CP	100	IGS

Fig 12. Examination Screening/Defaulters List



4.0 Performance Evaluation

The metrics used for performance evaluation on this system are latency, speed with respect amount of data transferred, False Acceptance Rate (FAR), False Rejection Rate (FRR), Accuracy, Precision and Recall. The amount of data moved successfully from one place to another in a given time period, typically measured in bits per seconds (Bps) is referred to as throughput.

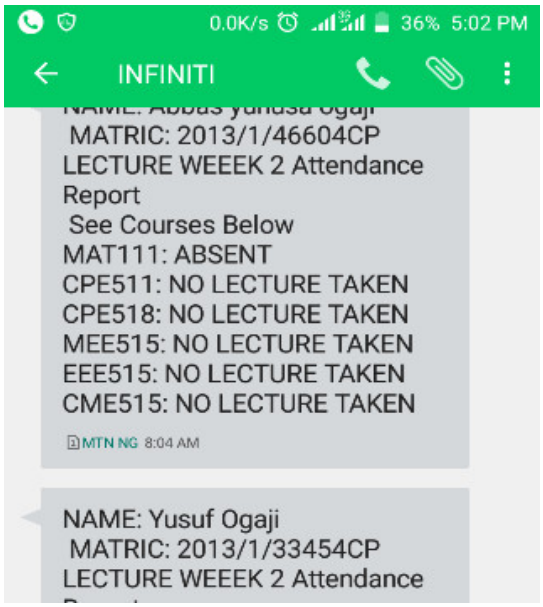


Fig 13. SMS Report Sent to Parent GSM device.

The Throughput of the system was calculated based on the data transmission of the AIFD file from a PC to the Raspberry pi-based attendance device. Factors that affect the throughput include, size of data, transmission protocol, communicating device computational power and transmission medium.

For the experiment 20 AIFD files was used, the first Five (5) files containing about 50 fingerprint data samples with 99KB size, the second set of files containing 100 fingerprint data and having a 187KB size, The third set of files is 899.5KB in size containing 500

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fingerprint data, While the Last Set of files is 1,799KB in size containing 1000 fingerprint data. The Attendance Device of some attendance systems can only manage 1000 fingerprint capacity, but the attendance device proposed for system makes use of real-time fingerprint data temporarily and uses smart data selection and filtering technique to select only data required for the live event, thereby reducing the amount of fingerprint data sent. The PC machine used for sending the AIFD file is a low-cost machine with Intel core i3 processor and 2GB RAM, while the receiving device has a 1GB RAM and 1.2 GHz ARM processor. An average throughput of 21.95Mbps was recorded.

Also, further experiments were undergone to show the system's latency This addresses the system's response time to triggers, the duration of acquired fingerprint image transfer, and the duration of attendance data communication. This is shown in table I. below.

In Comparison to the developed system in [1]. The fingerprint and RFID authentication procedure was used as a comparison metrics between the developed system in [1] and the proposed system. The result showed that the average execution time (3.58 secs) of the proposed system is lesser than that of the developed system in [1](4.29). One major reason that influences this result was the use of a smart data selection technique which reduced the search space used by the fingerprint in perform its one-many matching. Also the central controller used in the proposed system (Raspberry Pi 3 Model) provides more processing power with support for multithreading unlike that of the developed system (Arduino Mega 2560) in [1]. Table 2 shows the comparison of execution time of the developed system in [1] and proposed system.

Table 1. Overall System Latency

S/N	Period	Min Delay (s)	Max Delay (s)	Average Delay (s)
1	Start up	4	8	6
2	Fingerprint/ RFID Enrolment	5	10	7.5
2	Attendance instruction set-up	4	6	5
3	Attendance instruction/fingerprint data transfer	0.05	0.15	0.1
4	Attendance instruction/fingerprint data initialisation	4	50	27
5	Real-time Attendance record transfer	0.3	0.5	0.4
6	Validation	1	5	3.5
7	RFID response time	1	3	2

Below shows a graphical chart representing the table below;

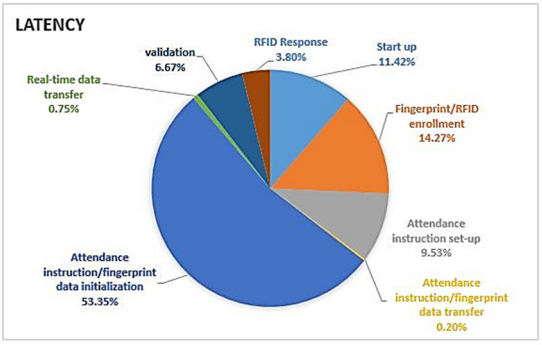

Fig 14. Overall System Latency.

Furthermore, the performance of the system in terms of false acceptance recorded a 0% FA rate. As the system has double-layered security built in, it successfully guards against mistakes that could allow access to unauthorised users.

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Table Ii. Comparism of Execution Time

Students	Fingerprint and RFID	Fingerprint and RFID Using smart data selection and filtering technique
1	4.06	3.47
2	4.30	3.73
3	4.90	4.25
4	5.17	4.03
5	4.79	3.64
6	4.66	3.36
7	4.70	3.22
8	3.95	3.14
9	5.24	3.98
10	4.31	2.99

5.0 Conclusion and Recommendation of Work.

In this paper, we presented a smart real-time attendance system using smart data selection and filtering technique. the developed prototype successfully captures and extracts fingerprint data of new students, reads RFID tags, transfers fingerprint and attendance data via a Wireless LAN (Wi-Fi), smartly selects a more reduced and simplified data needed for the live attendance event during authentication/attendance process, produces an output in form sound from the buzzer, generates attendance report using the attendance management software and sends SMS report to parents of students.

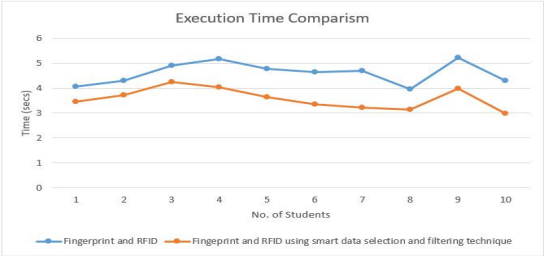

Fig 15. Comparison of a Fingerprint-RFID system and Fingerprint-RFID system using smart data selection and filtering technique.

By using the smart data selection technique, only the data required for the attendance event in question is sent, avoiding the sending of unnecessary data that is retained in the database. The attendance instruction and fingerprint data configuration file (AIFD file) carrying data of 1000 users has an average size of 1,799KB with an average transfer speed of about 0.13 seconds over the Wi-Fi network.

Consequently, the fingerprint sensor's flash memory should be used to store fingerprint data statically rather than utilising an independent attendance system. It would be better to make use of a system that receives properly selected and relevant fingerprint data based on the event in view, temporary storing them in in the fingerprints flash memory and wiping fingerprint data off once attendance has been completed making it a volatile and less memory dependent system. Although no system is perfect so there is a need to address the following issues;

The System can be further enhanced by replacing the RFID and incorporating the upcoming biometric systems like the Heart Pulse biometric scanner or Palm Vein Scanner coming into play in future times.

The system can be integrated with other systems, sensors, or actuators to provide more control and automation on other devices or

objects like classroom doors, classroom cameras, and classroom appliances like doors opening automatically when the attendance system verifies the student establishing a powerful networked system.

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