BIOMETRIC FINGER PRINTS SECURITY SYSTEM FOR CLOCK-IN AND CLOCK-OUT FOR PRIMARY SCHOOL

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ABSTRACT

The security of lives and property in any society is indispensable. Security is a major concern for any government in the global community, Nigeria is currently be devilled with security challenges such as kidnapping and abduction. The high rate of abduction of school children in the country has become increasingly alarming, and the educational institutions are gradually becoming a source of hostility and nightmare for primary school pupils. To overcome this problem, a web-based clock-in and clock-out biometric fingerprint technology security system was implemented effectively to recognize who picks up a child from school and to recognize the student clock all day. The implemented system is recommended for use in all primary school, as it greatly reduces the risk of impersonation during pupil's pick up hour in school.

Keywords: Fingerprint, Biometrics, Clock-in, Clock-out, Kidnapping, Abduction and Insecurity.

INTRODUCTION

The level of insecurity in Nigeria is alarming and perplexing. Nigeria as a country has encountered numerous turbulences, unrest, civil strife, drug trafficking, human trafficking, abduction, human sacrifice, ritual killing and armed robbery (Ilechukwu et al., 2015). The problem of insecurity is not peculiar to Nigeria, it is a global phenomenon as well. Kidnapping is one of the major challenges of ravaging the nation in all its insecurities. encountered. For this purpose, the menace of kidnapping in Nigeria has developed over the centuries into a persistent, omnipresent safety threat and a rapid and multifaceted criminal enterprise (William & Don, 2019. In public and private discussions, kidnappings have become the subject of discussion because of its recurring incidence in the country. Literally, the term kidnapping has gained notoriety, putridness and nausea in nearly all nooks and cranies of global community in which Nigeria is not an exception. "kid" meaning child and "nab" means to snatch (Ngwama, 2014). Churches, mosques, markets, businessmen, politicians, traditional leaders and their family members, religious leaders and public servants including school childrenare all vulnerable to this threat, so this level of insecurity is not left to anyone. The psychological negative consequences being experienced by the victims of kidnapping are enormous, particularly for a kid and this include anxiety, depression and Post-Traumatic Stress Syndrome (PTSD), also this may linger in the memory of the victim for a lifetime (Okwuagbala, 2019). Insecurity is an obstacle to education as the rate of abduction of primary school pupils in the country is alarming, and for this reason, not all institutions of learning should be a source of hostility to a child. In this developmental era, education is a veritable tool for success in life, moreover it requires safe learning environment, which will make the pupil socially, physically, mentally and emotionally complete (Akutu, 2017). These repeated attacks against children in schools are unconscionable as children have the right to education and protection and the classroom and school environment must be a place where they are safe from harm (UNICEF, 2018). In light of the above, this

research is aims to tackle the kidnapping and abduction of primary school pupils by designing and implementing clock-in and clock-out fingerprint technology-based security system to authenticate and recognize the identity of parent/guarding or their representative who come to pick-up their child/ward from school by drifting away from the manual paper and pen system that is currently practised in Nigerian schools. The proposed system is designed to be used in any elementary school around the world. This is to ensure the safety of elementary school students, as it will also increase parental trust in school authorities.

1. Literature Review

1.1 Biometric System

The term "Biometrics" consists of two phrases: Bio is a Greek word meaning Life and Metrics means Measurements. Biometrics is an information technology branch that seeks to establish a private trait-based identity. By definition, a biometric system is a technology which takes an individual's physiological, behavioural, or both traits as input, analyzes it and identifies the individual as a genuine or malicious user. Biometrics is used for authenticating and authorizing a person. It is the art of evaluating individual-specific physical or behavioural features for authenticating their identity. These features (physical and behavioural) are the two categories of biometric system (Biometrics, 2019).

1.1.1 Fingerprint Recognition System

Fingerprint recognition system is the most recognized and widely used technique to authenticate the genuinity of people identity in biometric systems. The major reasons why it is widely recognized, is for the fact that, there are ten (10) different types of biometrics and the ease of acquiring them. It is scientifically proven that every individual fingerprint is unique and is comprised of these notable features such as: ridges, grooves and direction of the lines. There are three (3) basic forms of ridges namely, arch, loop, and whorl. Fingerprint uniqueness is also determined by these features as well as minutiae features such as bifurcation and spots (ridge endings). There are three (3) basic types of fingerprint matching techniques as follows.

1.1.2 Minutiae-Based Techniques

Minutiae points are traced and then mapped to their corresponding location on finger. However, if the image is of low quality, it is problematic to locate minutiae points perfectly. An additional difficulty is that it does not consider the local position of ridges and furrows.

1.1.3 Correlation-Based Method

It is able to work with a low quality image because it provides solutions to the problems inherent with the smallest based technique. However, there is a problem with the localization of points.

1.1.4 Pattern-Based (Image Based) Matching

In this method, pattern-based algorithms compares the basic patterns of fingerprint (arch, whorl and loop) between a stored template and a candidate fingerprint (Physiological Modalities, 2019).

1.1.5 Fingerprint Biometric System

Fingerprint system was a discovery of the 19th century, it kept the criminal's fingerprints in a card filing database. To determine the criminals' identity, the fingerprints from the crime scene are drawn and mapped with this database. The fingerprint system has evolved as the computer is growing fast. An automated biometric system developed with comprehensive research and computer application. (Yahya et al., 2016). Fingerprint technology is one of the most recognized and widely used biometric system. Biometric fingerprint technology systems are smaller in size, easy to use, uses low power and it is a low-cost system as compared with other biometric systems. A typical fingerprint automated biometric system comprises of four (4) components namely image capture, feature extraction, pattern matching and database.

Figure 1 shows the fingerprint structure and Figure 2 shows the fingerprint biometric system structure(image capture component) in which, a sensor captures biometric data in a digital format for acquisition of data. An algorithm is obligatory for feature extraction component, to yield the feature vector which comprises of numerical characterizations of the biometrics of interest. In pattern matching, being the third component, a matcher

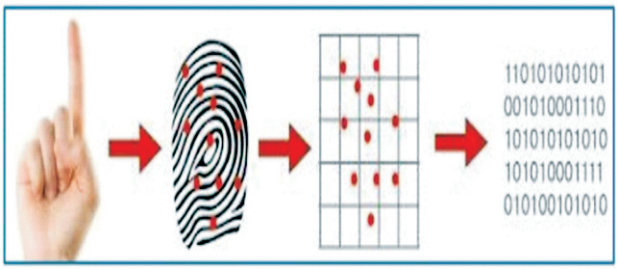

Figure 1. Fingerprint Structure (Physiological Modalities, 2019)

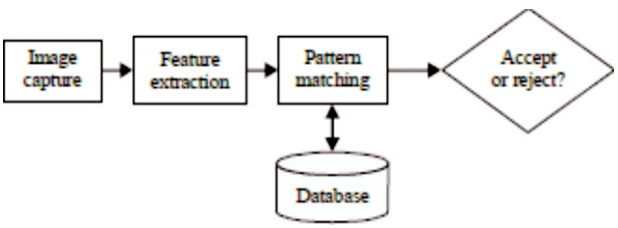

Figure 2. Fingerprint Biometric System Structure
Haidawati et al., 2016

compares feature vectors to get a score, which depicts the intensity of likeness between the biometrics pair of data under study. The results from this process is controlled by FAR and FRR2. The rate in which the system falsely accepted an unregistered or another registered user as a registered one compared to the total number of trials is called False Acceptance Rate (FAR). False Rejection Rate (FRR) occurred when the system falsely rejects a registered user in the total number of trials. A high FRR indicate a low FAR and a high FAR indicated low FRR. The best and ideal system should have moderate values of both.

1.2 Related Concepts

Dwi et al. (2019) proposed an attendance system by means of face recognition using Android smartphone in which the student face is captured. They argued that other previous biometric attendance systems are inefficient in terms of processing time and low in accuracy, this technique allows students to take attendance by themselves with the aid of their android device by capturing their face image scan it for Quick Response (QR) code. The server generated a QR code that would be displayed on a monitor located in front of the classroom. However, this system is a mere proposal as it was not implemented.

Almaqashi (2019) proposed a Global Positioning System (GPS) and Closed Circuit Television (CCTV) based security monitoring system for the security of school children so that the school monitoring team can track down the buses, plan the route, monitor driving and students behaviour. They can alert parents to the status of the children if they come to school and get home, and parents can also find a bus route. The real time data is transmitted from the tracking devices to software via cellular (GSM) network. This system only tracks the location of the school children as it does not reveals the exact identity of the child.

Nazleen and Rabu (2018) developed the system that enables students to take attendance using their smartphones to scan the unique QR-codes assigned to them, at the beginning of each lecture. The system delivers better attendance records than the conventional manual method that relies on sign-in sheet or roll calling student names, but it does not eliminate the chances of students signing up for others who may not be present as they can give their smartphone to another student to help scan and sign them in absentia. The system was limited to students of tertiary institutions and not primary school pupils.

Sarifah et al. (2018) aims to provide IT-based child protection that promotes the monitoring of children by parents and government. It was designed by engaging the geo-fencing technique and gravity sensor, using the sensing module triggers system to send alert to parents and system servers. The geo-fencing technique aims to activate the digital fence feature that allows parents to track the children. However, the geo-fencing technique enabled device may be misplaced thereby leaving the kid at the mercy of kidnappers.

Multimodal student attendance management system (MSAMS) presented a solution for the real-time student attendance management problem in large lecture halls (Mohammed et al., 2018). Radio Frequency Identification (RFID) and novel face recognition and identification approaches were proposed and evaluated. This system is however limited to large lecture hall class attendance as against daily school attendance.

Hendry et al. (2017) stated that the traditional and normal way of taking attendance by using pen and paper manually is unproductive, repetitive and tedious processes. Furthermore, it was noted that this old mode of taking attendance will incur time lost instead of delivering lecture effectively, especially if the population of a class was too large. To provide a solution to that problem, it proposed a smart attendance system which was developed by scanning the QR codes using a webcam attached to a computer. The Reed Solomon error code correction is applied to determine the authenticity of the code scanned through the webcam, although it does not have an efficient algorithm which is developed as a networked version.

Elshaiekh and Darai (2017) implemented a system that provides safer transportation for school students, especially for children who feel locked into a bus when they arrive at school, miss the bus, or cross the road without paying attention to traffic. The system was designed to check and detect any student entering into the bus not designated for them and monitor the entry and exit from the school using RFID (Radio Frequency Identification). Although RFID system is secured, there is a chance of abusing the cards. This research was limited to tracking student movement on school bus as it ignores their identity.

Choudhary et al. (2016) implemented a facial recognition system for taking and monitoring attendance. According to the study, the developed system uses the technique of facial recognition that automatically takes students attendance in the classroom without the student's intervention. The system uses a camera to capture the images of the student and conducts pattern matching in the database with current faces and indicates arrival. The facial recognition system for attendance management, may lack in the capability to differentiate facial features of identical twin brothers or sisters.

Anigbogu et al. (2015) implemented a web-based child monitoring system for monitoring children in the pre-school educational system, which allows parents to access real time information about their children or ward via their smart phone from a far distance. Web cameras are mounted in all the four (4) walls of classrooms and strategic locations within the school premises, which capture and store activities taking place in the classrooms and the school surroundings in the form of video. Parents need to log in to the web website and view the activities of their child or ward on their GPRS enabled phones or any device that has access to the Internet. This system however, does not guarantees the safety of the child as it only allows the parent to watch location of the child within the camera's coverage areas in the school only.

From the reviews of the aforementioned literatures, there is no research or study that adopted biometric fingerprints technology to tackle the problem of primary school pupils kidnapping and abduction. Due to this gap, this research was structured.

2. Research Methodology

2.1 Description of the Proposed System

The proposed system is a web-based biometric fingerprint technology security system for clock-in and clock-out that enables the secure pick-up of primary school kids from school by taking the fingerprint of the pupils and their parents or guardians respectively and also other means of pupil's pick-up, for example, school bus. The system uniquely clocks-in the pupil on their arrival to school using the pupil's fingerprint, and at the close of the school, the pupil can only be allowed to clock-out of the school with the authentication and authorization of their guardian using biometric fingerprint technique. In a situation where the pupil's guardian would not be able to come for the child's pick-up, the guardian is to call the school to request for a One Time Password (OTP) which will be generated and sent to the number in which parents or guardian registered during the period of registration. This OTP is then given to guardian, who will pass it on to the school authority for the student, without which the student will not be allowed to clock-out the school. However, with the exception of pupils who are of age and are allowed to go home by themselves, clock-out of such pupil is done by sending

Short Message Service (SMS) to their guardian to alert them of the current status of their child.

2.2 Flowchart of the Proposed System

The system flowchart shown in Figure 3 depicts the clock-in and clock-out process of the proposed system. After the system starts, it is logged-in by the school admin. The system via the admin checks if there are pupils to be clocked-in, if yes then it automatically checks if the pupil has clocked-in for the day (as pupil can only be allowed to clock-in and clock-out of the system once in a day). If no, it checks again if the pupil has been registered into the database before. If the pupil has been registered before, it inputs the fingerprint of the pupil and clock-in the pupil for the day and then go back to check the next available pupil. If yes, the pupil has clocked-in for that day, it inputs the pupil's fingerprint and verify the pupil's clock (which is done with the fingerprint of the pupil and parent/guardian), then it records the clock-out details into the database and go back to check for the next available pupil. If there is no longer any next available pupil, then the system will stops.

2.3 Proposed System Architecture

Figure 4 shows the architecture of the proposed system, which explain the behaviour and structure of the system. It illustrates how the actors communicate with the system. The system stores all enrolled bio-data of the pupil, guardian and bus driver into the database for easy access. The pupil clock-in and clock-out of the system with authentication and authorization. The guardian can communicate with the school using a mobile device for receiving SMS alert and request for an OTP from the school, the OTP is automatically generated and sent to the guardian's mobile device by the system, then guardian's trustee present it to the school authority to input into the system for authorization, if the parent / guardian is unable to pick-up the pupil.

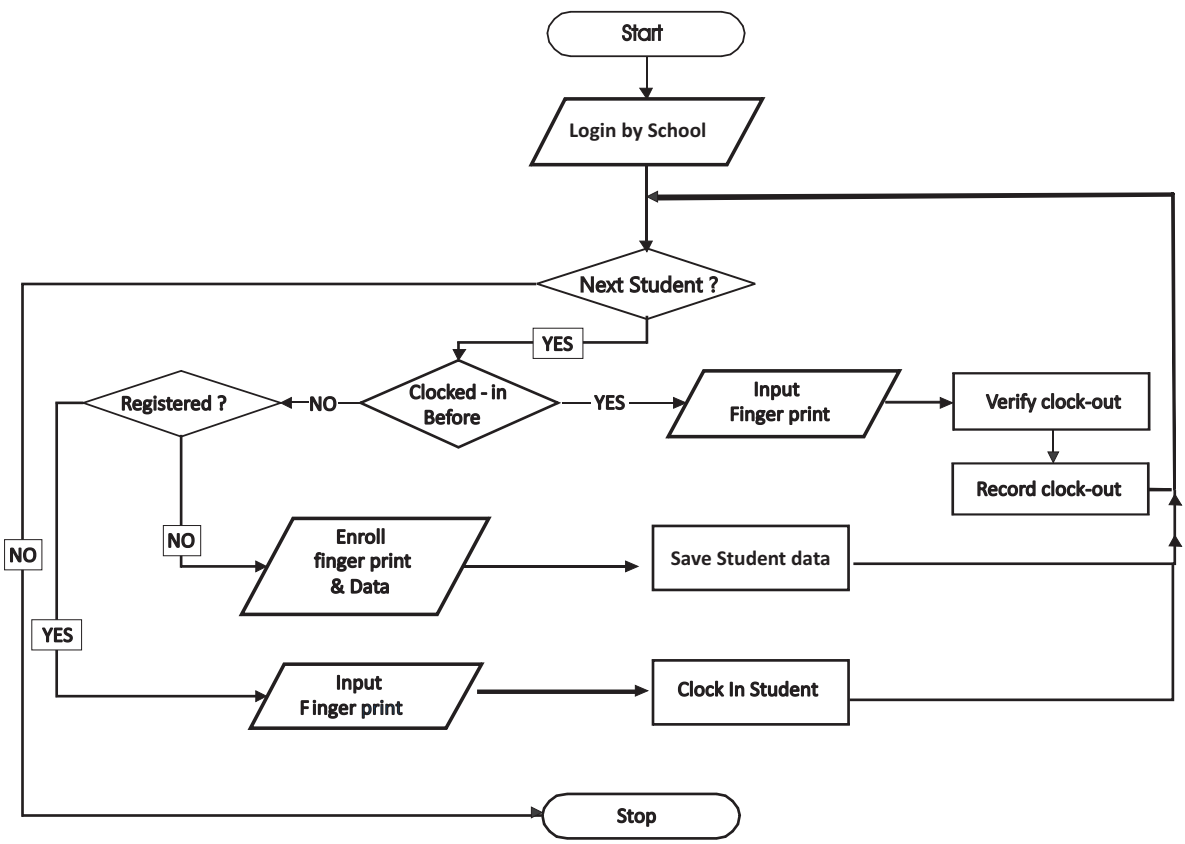

Figure 3. Flowchart for the Clock-In and Clock-Out Process of the Proposed System

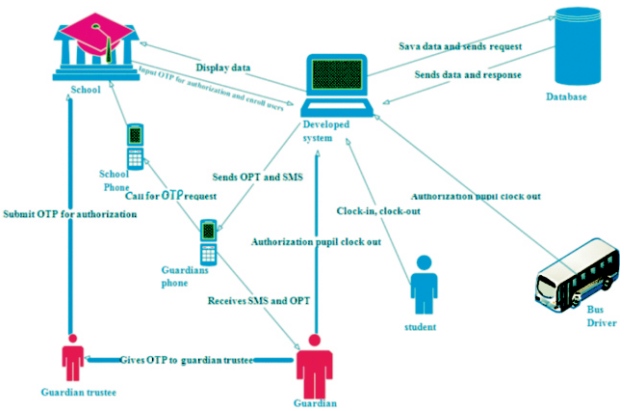

Figure 4. The System Architecture of the Proposed System

3. System Menus Implementation

3.1 School Login Page

This page is the first page that displays when the system is launched. In this page, the school sign-in using their password, as depicted in Figure 5.

3.2 Record Page

All records of clock-in and clock-out in the system are displayed in this page and also clock-in and clock-out is carried out in this page. As shown in Figure 6, there are four (4) types of clock-out button options namely, The Self clock-out button, OTP clock-out button, Guardian clock-out button and Bus clock-out button. Other buttons on the page are the button that shows the log of the major actors (student, guardian, bus) of the system, including the class log.

3.3 Student Enrolment Page

This is the page that enables enrolment of pupils bio-data into the system database. While enrolling, the pupil's fingerprint and passport, some other pupil's bio-data details

Figure 5. School Login Page

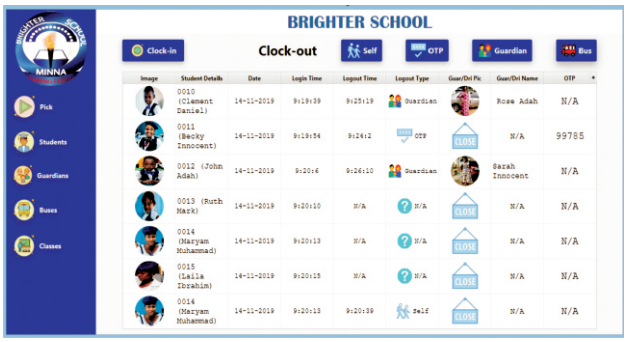

Figure 6. Record Page

such as the pupil's registration number, first name, last name, parent mobile number, pupil's class, address, date of birth. There is an optional button asking if the pupil will be self clocking out (going home without the company of parent/guardian). This is depicted in Figure 7.

3.4 Guardian Enrolment/ Record Page

This is the page where the registration of the guardians is captured and save in the system database for authentication and authorization, the passport and fingerprint of the guardian is captured and the guardian's first and last name. This is shown in Figure 8.

3.5 Bus Driver Enrolment/ Record Page

Figure 9 shows the page for enrolling the bus driver's bio-data, driver's passport, fingerprint, first and last name are

Figure 7. Student Enrolment Page

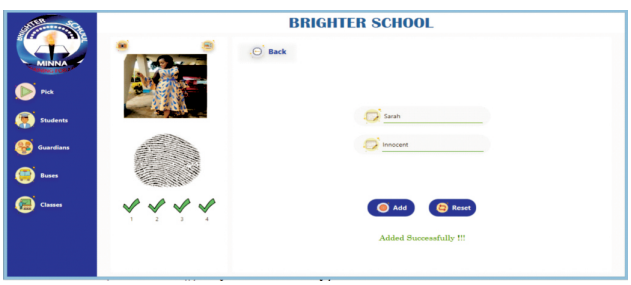

Figure 8. Guardian Enrolment Page

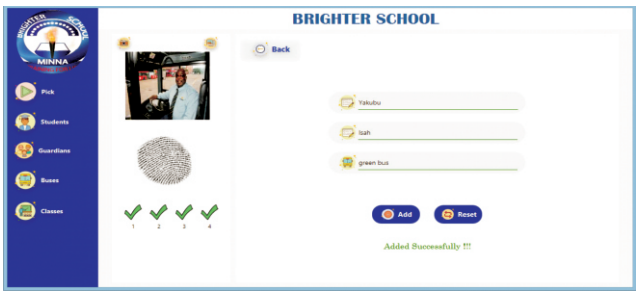

Figure 9. Bus Driver Enrolment Page

captured together with the identity of the bus.

Figure 10 is the bus pupil's link page; this pop-up dashboard is opened when the details of a bus driver is clicked on. It is used for link pupils to their various school buses for clock-out authorization.

3.6 Class/Grade Management Page

Figure 11 shows the class management page that contains the list of class added by the school admin and the add new class button where the addition of class is carried out.

3.7 Clock-in Operation

Figure 12 is a page that shows a successful clock-in by a pupil. This is done by clicking the clock-in button at the left side of the record page, a dashboard requesting for pupil's fingerprint will pop-up, if the fingerprint of the pupil

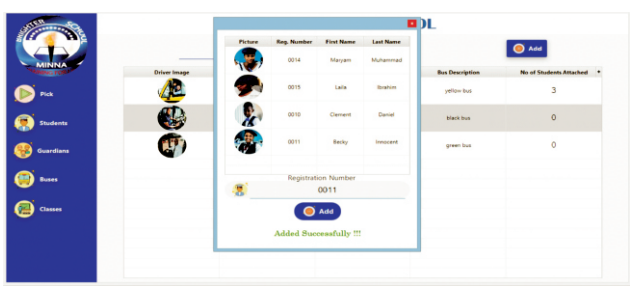

Figure 10. Bus Pupil Link Page

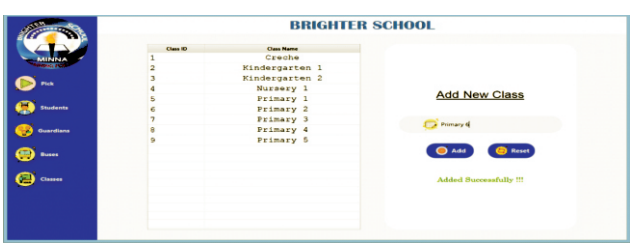

Figure 11. Class/Grade Management Page

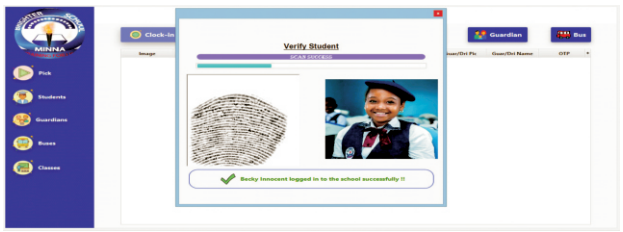

Figure 12. A Successful Clock-In

matches, the one in the database and the pupil has not able to clocked in for that day, it displays a success message, otherwise, it flags an error message.

3.8 Clock-out Options

The system has four (4) clock-out options namely, The Self clock-out button, OTP clock-out, Guardian clock-out button and Bus clock-out button.

3.8.1 Self-Clock Out

Figure 13 shows a page for self-clock out carried out by Maryam Muhammad, a pupil whose bio-data registration was marked to selfclock-out because the pupil is to be allowed to go home without any authorization. In Figure 14, an SMS alert is sent to the pupil's guardian at the point of clock-out.

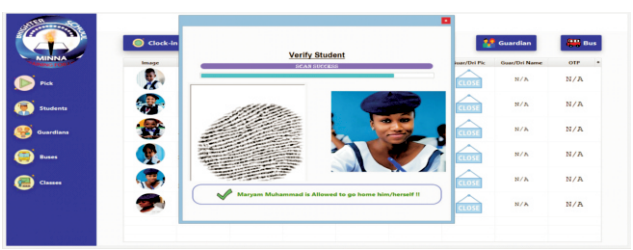

Figure 13. A Successful Self Clock-Out

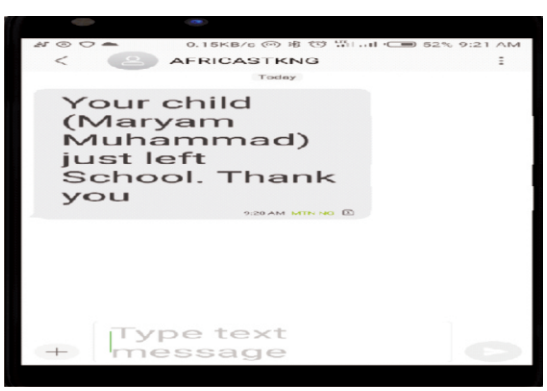

Figure 14. SMS Alert to Guardian Mobile Phone After Self Clock-Out

3.8.2 OTP Clock-Out

Figure 15 displays an OTP request page by a guardian (Rose Adah) for her child (Becky Innocent). The OTP option is used for guardians who will not be able to come to school for pick up their child in some situation. This option will enable the school to identify who the guardian has been sent to pick-up the pupil. In Figure 16, the OTP number is sent to the guardian phone number that was registered in the pupils bio-data.

Figure 17 shows an OTP clock-out page for trustee. After the OTP has been sent to the guardian, the pupil is to present the OTP to a trustee who is authorize by the parent to pick the pupil from school, the OTP is then inputted into the system through the interface displayed for authentication and authorization of the pupil clock-out. As shown in Figure 18, an SMS alert is sent to the guardian phone to notify the guardian of the clock-out.

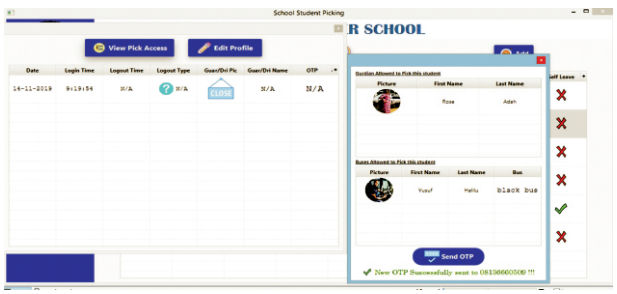

Figure 15. OTP Request Interface

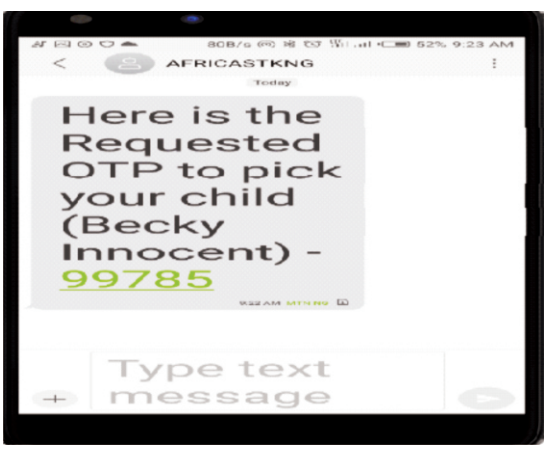

Figure 16. OTP Number Sent to Guardians Mobile

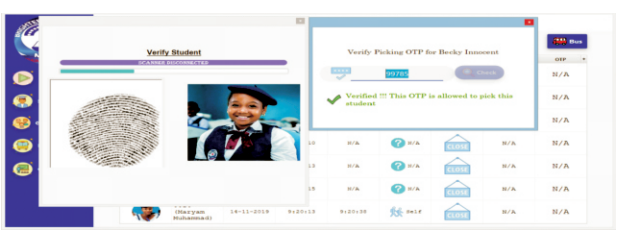

Figure 17. A Successful OTP Clock-Out Page

3.8.3 Guardian Clock-Out

Figure 19 shows a guardian clock-out page. When a guardian clock-out button is clicked then the page for pupil's fingerprint is displayed, once there is a match, another fingerprint page is displayed in the side of that of the pupil, if the guardian's fingerprint is verified, the pupil will be clocked out.

3.8.4 Bus Clock-Out

Figure 20 shows a bus driver clock-out authorization page.

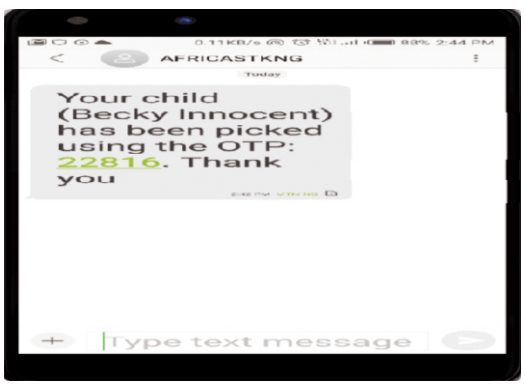

Figure 18. SMS Alert Sent to Guardian Mobile Phone after OTP Clock-Out

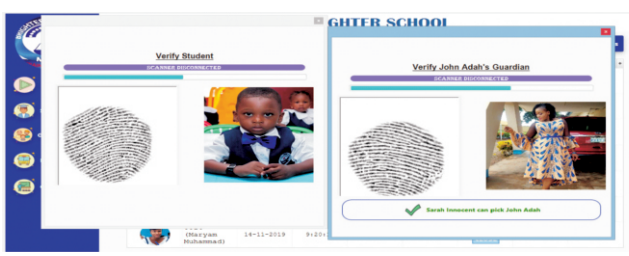

Figure 19. A Successful Clock-Out by Guardian

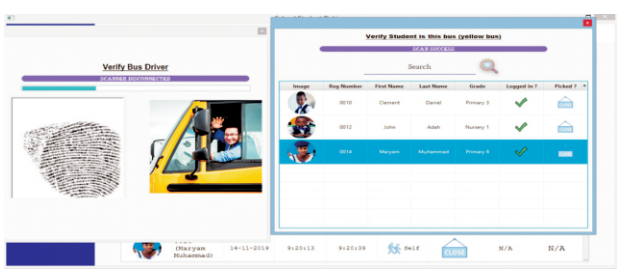

Figure 20. A Successful Bus Driver Clock-Out Authorization

When the bus clock-out button is clicked, a fingerprint page for the bus driver is displayed, when there is a fingerprint match, then page of all the pupils linked to a particular bus is displayed and each pupil is to input their fingerprint for authorization, when the fingerprints are matched, it reflects that the pupil has clocked-out for the day, and an SMS alert is sent to the guardians phone as shown in Figure 21 below.

3.9 System Usability Testing Evalution

Table 1, shows the system usability testing validation which was used to calculate the accuracy rate of the system. In the system testing, 52 respondents comprises of 10 web developing experts, 14 school managers, 7 parents/guardians, 18 pupils and 3 school bus drivers were randomly selected in Minna, Niger State, Nigeria. 95% for the ease of learning, 75% for intuitive design, 100% for efficiency of use, 80% for memorability, 75% for error frequency and severity, and 80% for subjective satisfaction. With the details from Table 1, the overall accuracy of the system is calculated below.

$$\text{Total accuracy} = \frac{95 + 75 + 100 + 80 + 75 + 80}{6}$$

$$= 84.2\% \text{ Accuracy.}$$

Figure 21. SMS Alert to Guardian Mobile After Bus Clock-Out

Test Type	Very Good	Good	Poor	Accuracy
Ease of Learning (10)	9	1	0	95%
Intuitive Design (10)	7	2	1	75%
Efficiency of Use (10)	10	0	0	100%
Memorability (10)	8	2	0	80%
Error Frequency and Severity (10)	7	2	1	75%
Subjective Satisfaction (10)	8	2	0	80%

Table 1. System Usability Testing Accuracy Table

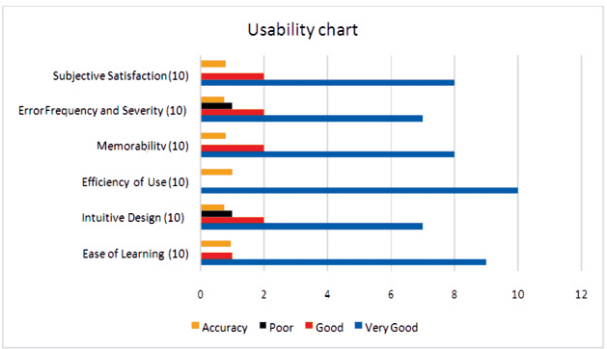

Figure 22. Usability Chart

From the above result, the accuracy of the system is good, and this evaluation result has proven to be reliable and efficient for the system and is recommended to use for pupil's clock-in and clock-out.

Figure 22 shows the chart of the usability evaluation.

Conclusion

A web-based clock-in and clock-out biometric security system was implemented for primary school pupils using fingerprint technology. The system captures and stores the fingerprint of pupils, and link it to that of their parents/guardians for authentication and authorization. The menace of impersonation during pupil's pick-up time is settled with the implemented system. In addition, the system will enable schools to keep a safe, secure and trusted academic environment and thereby drastically reduce the rate of pupils kidnapping, rape and missing kids.

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