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Development of a Fingerprint-Inspired Hostel Access Control

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Abstract*: Access control (AC) is the process of selectively restricting access to a location or resources up until authorization is obtained. Theft, kidnapping, and murder are all on the rise in Nigeria due to the growing issues with property and life insecurity. Additionally, burgling, thefts, rapes, and other crimes involving forced or covert entry into the dorms for students have crept onto the campus as a result of the facility's open access. A fingerprint reader can be used as an efficient authentication access control to limit illegal access to hostel environments considering these threats. This becomes crucial as practically all students attend lectures, while the poor ones or even strangers break into their dorms and steal their belongings, including money, jewels, and expensive devices. In this study, we used a discretionary access control model and a single layer access control component (a fingerprint sensor) to design a digitalized biometric hostel access control system using Bluetooth remote data logging that automatically records hostel attendance. This system will replace the conventional method of manually checking in and out of the hostels.*

Keywords: *Authentication, access control, biometric, gate, hostel.*

1. INTRODUCTION

To prevent an unauthorized person from forcibly entering a physically or logically protected site, access control is a security mechanism that limits who or what can be observed, gained, or accessed in a physical or digital ecosystem. Meanwhile, two classes of access control exist, which are Logical and Physical.

Access to tangible locations, such as dormitories, campuses, houses, rooms, and physical IT assets, is restricted by physical access control. Logical access control restricts access to databases, file systems, and network services, among other things to track student movement and allows or restrict access to restricted locations.

While some of these systems may only restrict access, others may be more complex and include alerts and lockdown features to stop unwanted entry or operations. To identify, authenticate, and authorize individuals and entities, access control systems evaluate the necessary login credentials, which may include biometric scans, security tokens, personal identification numbers (PINs), passwords, or other elements for authentication. To put it another way, these security measures function by identifying an individual or organization, confirming that the person is who they say they are, and approving access. After that, a sequence of activities, such as opening a door, recording attendance, or gaining access to operate a machine, happens etc. [1-5]. This study proposes an electronic access control system, a biometric access system that employs electronics to overcome the drawbacks of mechanical systems. Based on the authentication that is provided, the electronic access control system authorizes access. The door unlocks when entry is given for a predetermined amount of time, and the operation is captured and forwarded to a distant computer, which includes PC or phone. The door stayed locked when entry is denied, and the unsuccessful access is noted. The system will also watch the door and sound an alert if it is forced open or left open for an extended period after being unlocked. A control panel, a highly dependable processor, receives information about a credential when it is provided to a viewer. The control panel authorizes or declines the submitted query, sends a transaction history to a database, and checks the credential's number to an access control list. The door stays locked when entry is refused in accordance with the access control list. The control panel activates a relay,

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which then unlocks the door, if the credential and the access control list match. The reader frequently provides feedback, such as an LED that flashes or a buzzer that beeps when access is granted or denied. [1-10].

2. LITERATURE REVIEW

On the basis of various technologies, a variety of research projects have been designed and implemented in access control and identification systems. Despite these IT-based developments, each technology has pros and cons of its own. Although keeping a record attendance is a crucial part of people administration. Managing people is a challenging experience for most firms. A solution has been devised to address this issue; it uses a fingerprint sensor to digitally take attendance, and all the recordings are stored on a computing device. Each room's entrance has LCD panels and fingerprint sensors. The student must place his or her finger on the fingerprint reader to record their attendance. Following recognition, the database's record attendance for the student is modified, and an LCD panel alerts him or her of the change. The solution will reduce the number of labours required by the management, saves time, and replaces stationery supplies with electronic equipment. RFID and biometric technology integration will raise the level of security in the boarding school administration system. [10-12]. The use of a boarding school surveillance system will enhance school administration processes, automatically track the mobility of interest groups, and enhance asset security. This has significant implications for surveilling BS assets and reduces the responsibilities of school administration while freeing up time for a variety of student activities. The technology reads information from the RFID tag and sends it to a database so that BS management may examine the access data online for monitoring purposes when the metric card goes through the RFID reader. When a person with an RFID tag enters a facility room, RFID will be identified and verified by a matching fingerprint image.

As the fingerprint approach is among the most widely used software in both recognition and verification utilizing biometric devices, the fingerprint matching based on minutiae matching was proposed in [6–8]. The minute matching method extracts minute features from the fingerprint image and compares them to sets of fingerprint features. Following verification, it shows the user's identification and confirms the fingerprint. However, a biometric identification-based approach is typically employed to identify students [9]. The system also successfully recorded attendance for both lectures and exams, which is an improvement above the manual attendance management approach where attendance is noted after student identification. The prototype was successful in capturing fresh fingerprints to be added to the database as well as scanning and comparing fingerprints placed on the device's sensor to fingerprints already present in the database [6–12]. [12] suggested a GSM and RFID-based Smart School Management system with assistance from Advanced Embedded Systems. The Global System for Mobile Communication (GSM) is a quick and effective method for quick reporting and real-time object identification [13–14]. The student is observed by the RFID system. The created model is tested in a lab setting, and the findings are examined. At the laboratory scale, the effective implementation of RFID-assisted GSM technology has been successfully designed. The level of security and accuracy could be raised to the public. The advancement of GSM and RFID technology continues to produce real-time systems with quicker processing speeds, larger memory capacity, and broader reading ranges.

Biometric technology is a useful tool for confirming identity and spotting fraud [15–20]. Analysis proved that the biometric information may be set and used to establish the user's identification. Expanding the use of biometrics will improve our ability to identify fraudulent activities when students are in class or employees are at work. The system can be improved to track the students or employee's arrival and departure times for more surveillance system. The technique was suggested by Amol et al. to give the hostelled females security while also saving time [20]. The solution makes use of the Real Time Security Management System, which makes security monitoring in large organizations efficient and simple. The security management is more effective and dependable because to real-time status monitoring and intelligent massage. Although it can be utilized for recognition, an RFID card is not secure. Because each person has a unique design pattern on their finger, we employ fingerprint technology to solve this issue and prevent anyone from using the other name [10–12].

3. PROPOSED DESIGN AND METHODOLOGY

Establishing the necessary criteria and creating a block diagram (Fig. 1) to show the signal-flow between the various components of the system are the initial steps in designing an electronic system. A suitable circuit was selected for the design, considering how well these blocks matched, from a list of possible circuits. Choosing the compatible circuit among the numerous available options, as opposed to one that fulfils a special purpose, is a huge challenge for the developer. The following flowchart serves as an illustration of the entire design process (Fig. 2).

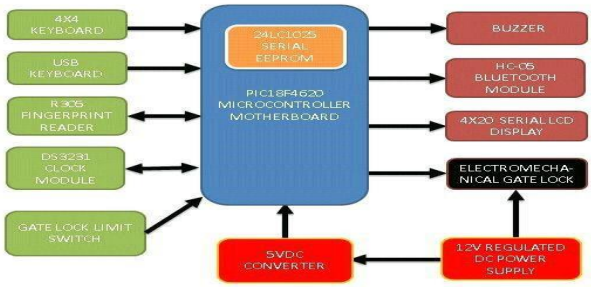

Figure 1: Block diagram of the hostel access control system [16]

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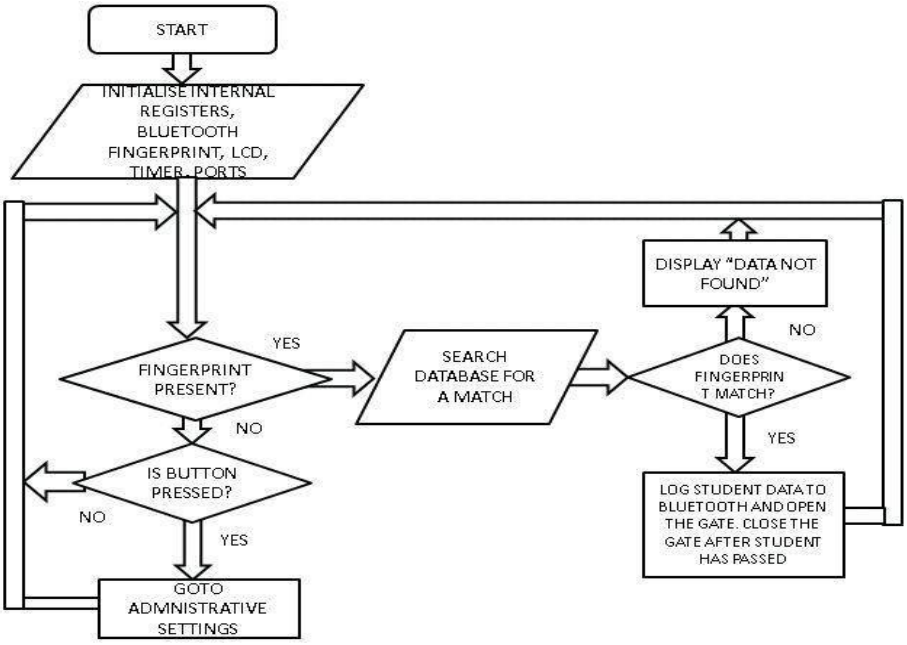

Figure 2: Control flowchart of access control system [19]

4. CIRCUIT DESCRIPTION AND OVERVIEW

The PIC18f4620 microcontroller, which performs all essential operations, is the circuit's brains. It is supplemented by peripherals such as the EEPROM, HC-05 Bluetooth, and DS3231 timer chip. One of the key inputs to the system is the R305 fingerprint reader, which also serves as the keyboard for text input. The system's primary output is the gate lock actuator, which closes the gate by default and only opens it after receiving instruction from the microcontroller to do so after approving the student whose finger is placed on the fingerprint reader. A 20x4 LCD with an audible buzzer and Bluetooth to log a softcopy to a Bluetooth device is another output.

The firmware executing in the hardware circuit, which is written in the C-programming language and built by the CCS PIC C compiler, enables the coordinated operation of the hardware circuit. As a result, the following is the general basic mechanism of the hostel access control system: The user, who may be the hostel manager or security personnel, must first register the students by collecting their biodata, which may include things like their name, matriculation, phone number, sex, fingerprint, etc. To obtain access, the administrator must enter a password, which they can modify as needed. The system records the fingerprint picture into the fingerprint sensor after the student's information has been entered, and it also assigns the spot a pattern number that is eternally recorded in the EEPROM.

For student to gain access to the hostel, the system flashes the light on the fingerprint sensor. This sends signals to the learner or user that the system is ready to read a fingerprint. The system matches the finger place with the ones stored in the memory. If there is a match, the system gives signal to the gate lock actuator to open the gate, then it locks the gate when the limit switch has detected that the person has passed. The student’s name and matric number and date/time will also be logged on the remote Bluetooth device. The system will display "DATA NOT FOUND" and the gate can't close if it can't match the fingerprint.

5. CIRCUITRY COMPOSITIONS

The power supply powers every input, output, memory device, and other peripheral component as soon as the circuit is turned on. All of the peripherals initialize and are prepared to perform their various roles as soon as they are powered (Fig. 3). The microcontroller is prepared to transmit instructions, receive input from the fingerprint reader, and show some data on the LCD while the timer chip is ready to save data on an external memory as required. The microcontroller clocks the CPU at32 MHZ, which allows it to perform 8 million instructions every second (1 instruction takes 4 clock cycles). This speed is required for the microcontroller to do numerous bulky tasks quickly, including simultaneously decoding data from the keyboard and keypad, accessing 65,000 EEPROM memory locations, displaying data on a 20X4 pixel LCD screen, and other tasks.

Without the assistance of the primary microprocessor, the DS3231 timer chip enables the system to keep time and date on the underground. The microprocessor only sets the timer chip when the user is setting the time and date; when the time comes to show the time and date, the microcontroller then retrieves the time and date data from the timer chip. When the system's power is turned off, the backup CMOS battery keeps the clock running. The microcontroller's memory space is increased by the EEPROM so that it can accommodate more student information. The main microcontroller is connected to

the timer chip and the EEPROM through two pins, SDA and SCL, which stand for serial data and serial clock, respectively. A pull-up resistor is placed between those pins and VCC.

The microcontroller sends an instruction to the fingerprint module to check for fingerprint matches, or to erase or store fingerprints. The fingerprint module is in charge of reading fingerprints. The UART protocol is used by the microcontroller to connect to the fingerprint module. The fully prepared Bluetooth module simply accepts ASCII characters from the microcontroller and broadcasts the characters to the computer or phone it is paired to. In the user settings or the system settings, the pairing password can be modified.

A. Circuitry Algorithm

The software is written in C (C language), an embedded system's programming language. This software is loaded into the microcontroller using PICKIT2debugger and the software algorithm shown below and the corresponding flow chart (Fig. 2).

1. Start
2. Initialize the LCD, EEPROM, fingerprint, internal registers, and ports.
3. Get date and time from DS3231, check Bluetooth status, check menu button status and display it accordingly.
4. Verify whether a finger is present on the fingerprint module; if not, proceed to step 3, if a finger is there, step 5, and if a menu button is touched, step 8.
5. In the fingerprint module, read the student's fingerprint.
6. Database search for a match if there is a match, move to step 6; if not, the message "DATA NOT FOUND" appears.
7. Show student's data, send an open command to the gate lock actuator, and send the details of student to the Bluetooth device. Send a close command to the actuator when student has passed. Go to 3.
8. "Enter password" is displayed. Go to 9 if the right password was supplied; otherwise, go to 3.
9. Menu is displayed to perform different operations and settings. After the operation, and ESC button is pressed go to 3.

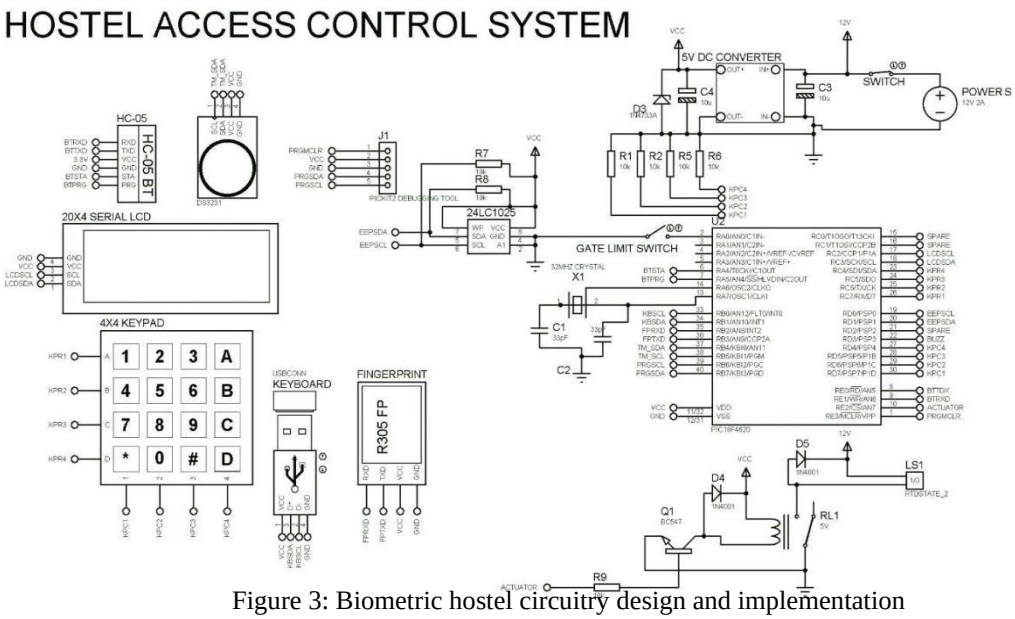

Figure 3: Biometric hostel circuitry design and implementation

6. THE MODEL GATE

The casing (Fig. 4) of the project provides a frame to fix different component that makes the project and also serves as a protection of the circuit from physical factors like rain, dust etc. it also protects the use from the risk off electric shock because there are some parts of the circuits (Fig. 7) that is high voltage. Hence, a good casing is to be chosen which is not too big or small but moderate to house all the components of the project conveniently. The gate model (Fig. 5) is to be constructed using wood, plastic and metal.

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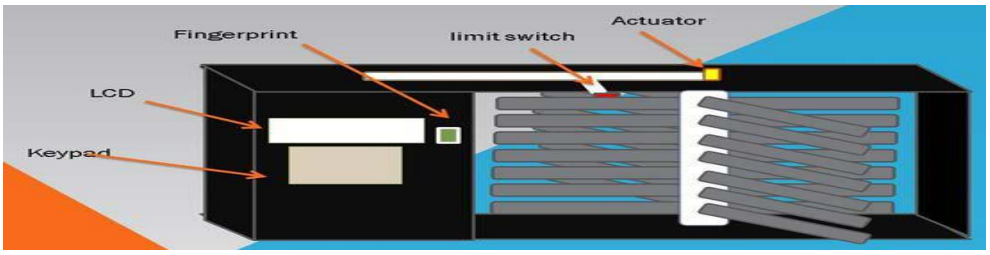

Figure 4: Proposed design of the hostel access control system

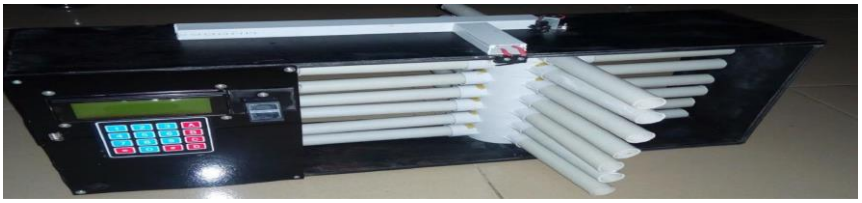

Figure 5: Actual design of the hostel access control system model

Figure 6: PCB design on proteus.

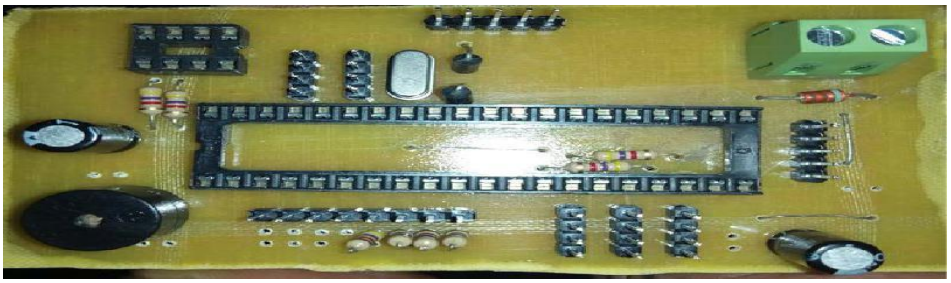

Figure 7: Mounting of components

A. Construction of the model gate:

Adequate measurements were taken for the construction of the wood casing to develop a model gate. However, the wooden casing was painted before mounting all the design components as shown in the construction design phases (Fig. 8)

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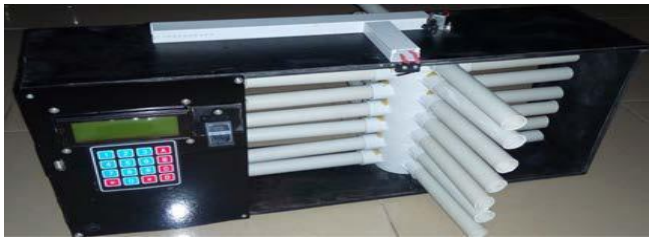

Figure 8: Construction phases

7. SYSTEM CONFIGURATIONAL ANALYSIS AND TESTING

Designed system was tested module by module on a breadboard before constructing it on PCB before being simulated and debugged on Proteus using four modes: access control mode, free access mode, permanent lock mode and permanent unlock mode. The Bluetooth transceiver was also tested; the name and password were programmed with AT commands with a USB to TTL converter.

The system is powered by a 12vdc power supply and the input is 220vac according to the scope of study, but for emergency purpose, it can be powered by a 12vdc car battery or simply a 12v 7Ah UPS battery. All components in the circuit uses 5vdc except the actuat or that uses 12v. The stepdown converter converts the 12v to 5v with 90% efficiency. The peakpowers consumed by the major components are as follows:

Microcontroller 50mA x 5v = 250mW

R305 200mA x 5v = 1000mW

Hc05 Bluetooth 100mA x 5v = 500mW

LCD 70mA x 5v =350mW

Keyboard 100mA x 5v = 500mW

Ds3231 30mA x 5v =150mW

EEPROM10mA x 5v =50mW

Actuator 1000mA x 12v =12000mW

The total power consumed is: 12000+150+50+500+350+500+250+1000 =14800mW

The whole circuit consumes approximately 15W,

The circuit is powered by a 12v 2A=24W

Using a 12v 7Ah battery=84Wh

The circuit will be powered for 84Wh/15W=5.6h

Using a 12v 100Ah battery = 1200Wh

The circuit will be powered for 1200Wh/15w= 80h (3 days)

The database schema was designed and grouped into sections to hold the following fields: Registration status, student access time and date, name, matric number, gender, hostel number, telephone number (Table 1). Meanwhile, the fingerprint image is stored inside the fingerprint reader serially in accordance with the order of the student data stored in the EEPROM. The database is organized as follows (Table 1):

100 bytes is allocated to hold the data for one student. The EEPROM memory is 65000 byte sand it is designed for 300 students. The total number of memory space used by 300 students is 300*100=30000. The 35000 space remaining is reserved for future upgrade.

The Snapshots of the completed and working system according to the aim and objective of this research is as shown below (Fig. 9).

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Table 1: Database fields & memory schema

Character Field	Memory Space (0-99)	Number of byte for field
Registration status	0	1
Serial number	1	1
Attendance time	2-4	3
Attendance date	5-7	3
Blacklist status	9	1
Matric Number	10-29	20

Figure 9: Final constructed system

8. CONCLUSION

The goal of this study was to design and build a hostel access control system using embedded systems, digital electronics, circuit design, and key hardware components including a microcontroller, fingerprint sensor, LCD display, actuators, etc. This goal has been achieved. In the meantime, adding voice recognition to the fingerprint-based multi-layer access control system gives the system further security capabilities. However, a remote embedded server should be included to store biometric information in the event that IoT (Internet of Things) hardware were to be physically destroyed in the near future.

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REFERENCES

[1] Kawaguchi, Y., Shoji, T., Lin, W., Kakusho, K. & Minoh, M. (2005). *Face Recognition-Based Lecture Attendance System, in Proceedings of the 3rd AEARU workshop on Network Education*, 70-75.

[2] Jha A. (2006). *Class Room Attendance System Using Facial Recognition System* International Journal of Mathematics, Science, Technology and Management, 2(3).

[3] Shoewu, O.O., Akinyemi, L.A., Mumuni, Q.A., Ajasa, A.A., Folorunso, C.O. & Edozie, R. (2022). Development of a Smart Attendance System Using Near Field Communication (SMAT-NFC), Global Journal of Engineering and Technology Advances, 12(02), 121-139.

[4] Akinyemi, L.A., Shoewu, O.O., Makanjuola, N.T., Ajasa, A.A., & F.O. Edeko (2014). Design and Development of a Radio Frequency Identification (RFID) Based Library Books Security System, *African Journal of Computing & ICT (IEEE, Computer Section, Nigeria)*, 7(2), 85-92.

[5] Akinyemi, L.A., Shoewu, O.O., Makanjuola, N.T., Ajasa, A.A. & Folorunso, C.O. (2014). Design and Development of an Automated Home Control System using Mobile Phone, *World Journal Control Science and Engineering*, 2(1), 6-11.

[6] Nawaz T. & Pervaiz, S. (2009). *Development of Academic Attendance Monitoring System Using Fingerprint Identification*, International Journal of Computer Science and Network Security, 9(5).

[7] Patel, H. & Asrodia, P. (2012). *Employee Attendance Management System Using Fingerprint Recognition*, International Journal of Electrical, Electronics and Computer Engineering, 1(1), 37-40

[8] Folorunso, C.O., Akinyemi, L.A., Ajasa, A.A. & Oladipupo, K. (2015). Design and Development of Fingerprint Based Car Starting System, in Proceedings of NIEEE's *International Conference and Exhibition on Power and Telecommunications*.

[9] Shoewu, O.O. & Idowu, O. A. (2016). *Development of Attendance Management System using Biometrics, The Pacific Journal of Science and Technology*, 13(1)

[10] Abdul Kadir, H., Abd. Wahab, M.H., Zarina, T., Mohd, R., Mohd, T. & Mohd, M.N.H. (2010). Fusion of Radio Frequency Identification (RFID) and Fingerprint in Boarding School Monitoring System (BoSs), Sustainable Radio Frequency Identification Solutions, Cristina Turcu (Ed.), ISBN: 978-953-7619-74-9

[11] Akinyemi, L.A., Shoewu, O.O., Makanjuola, N.T., Ajasa, A.A.& Edeko, F.O. (2014). Design and Development of a Radio Frequency Identification (RFID) Based Library Books Security System. *African Journal of Computing & ICT ,7(2),* 85-92.

[12] Sivasankaram, V. & Muruganand, S. (2013). *Advanced Embedded System Assisted GSM and RFID based Smart School Management system*, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 2(7).

[13] Farooq, U. & Hassan, M. (2014). *RFID Based Security and Access Control System*, International Journal of Engineering and Technology, 6(4).

[14] Akinyemi, L.A., Shoewu, L.A., Makanjuola, N.T., Ajasa, A.A. & Folorunso, C.O. (2014). Design and Development of an Automated Home Control System using Mobile Phone, *World Journal Control Science and Engineering*, 2(1),6-11.

[15] Priya, G. L, Pandimadevi, M. & Ramya, P. (2014). *Implementation of Attendance Management system using SMART-FR*, International Journal of Advanced Research in Computer and Communication Engineering, 3(11).

[16] Shoewu, O.O., Makanjuola, N.T. & Akinyemi, L.A. (2018). Smart Attendance Management System (SAMSYS) for an Academic Institution, Journal of Data Research, 2(1), 120-131.

[17] Shoewu, O.O. & Akinyemi, L.A. (2019). Enhanced Biometric Based Attendance Module Interfaced with POS, in Proceedings of IEEE African Conference

[18] Shoewu, O.O., Akinyemi, L.A., Lawal, R.A. & Otagburuagu, O.R. (2020). Enhanced Smart Biometric Based Attendance (ES2BASYS) System Interfaced with POS Facility for Smart Academic Institution, the Pacific Journal of Science and Technology, 21(2), 1-12

[19] Shoewu, O.O, Ayangbekun, O.J., Adedoyin, M.A., Aigbovbiose-Job, E, Akinyemi, L.A. & Folorunso, C.O. (2020). Design and Development of Health Centre Management System with Fingerprint Identification, the Pacific Journal of Science and Technology, 21(2), 1-12,

[20] Sapkal A. & Ingole, P. (2015). *Intelligent Security System for Girls in Hostel*, International Journal of Advance Research in Science and Engineering, 4(1).