NIPES

Journal of Energy Technology and Environment

Journal homepage: www.nipesjournals.org.ng

Near Field Communication Internet of Things (NFC-IoT) Based University Examination Monitoring System

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Article information

Article History
Received 4 May 2022
Revised 11 May 2022
Accepted 16 May 2012
Available online 13 June 2022

Keywords:
Near Field Communication, Microcontroller, University examination management system, IoT

https://doi.org/10.37933/nipes.e/4.2.2022.6

https://nipesjournals.org.ng

Abstract

The current university student examination management system and the challenges associated with it leave much to be desired. In spite of the proliferation of modern computing technologies in the education sector, the university management has continued to suffer from the manual process of performing academic and administrative functions of several institutions. For instance, the obsolete process of students' school fees receipt verification during examination has been found to be cumbersome as well as time consuming and could also distract the attention of the students while writing their examinations. The case is also the same for taking students' attendance. Over time, it has been observed that the manual method of examination invigilation and supervision has led to students deceiving invigilators by writing, answering or registering attendance in proxy for other students. This method also creates the room for students to outsmart invigilators by smuggling into the examination hall, scanned or forged identity cards and school fee receipts. In addition, valuable time is wasted on marking attendance of students who were present in the examination hall but did not enroll for the course because no automated system on ground to ascertain the eligibility of candidates for an examination. To solve these problems, Near Field Communication (NFC) technology is used in this work to process examination attendance registration and the school fee verification system. The test carried out on interfacing the various hardware and software modules shows that the system is efficient and reliable.

1. Introduction

The way and manner examinations are being conducted in our institutions of higher learning for instance, leaves much to be desired. The invigilators, most times, in a bid to take students attendance, verify their identity cards, and school fee receipts distract the attention of the students, disrupt the peaceful atmosphere supposedly permeating the hall and worst still waste much time taking students attendance.

The large number of students as well as the traditional approach creates serious flaws in the system [1]. Today, one of the innovative ideas in pervasive computing is the development of Near Field Communication (NFC) based on IoT technology. This technology would help, among other

functions, to automate students' examination management system so as to reduce the drudgery and ineptitude associated with the manual system [2].

NFC is a short range, low bandwidth, and wireless communication technology that is activated by touching two NFC enabled devices together, or bringing them into close range. It operates at a high frequency of 13.56 MHz [3].

NFC technology allows people to integrate their daily-use loyalty cards and credit cards into their mobile phones [4]. Thus, the data services received by the NFC based mobile phones during communication with other smart devices with NFC support placed closely may be used to access online applications or web pages. NFC technology also simplifies transactions and opens up innovative opportunities to mobile communications. This accounts for its wide application in commercial environments for bus ticketing, the mobile payment system, asset tracking, access control, counterfeit detection, and many more to mention but a few. Another attractive feature of the NFC technology is the ease of communication and the protection (or security) of personal property and information during and after communication. The short distant-communication between NFC enabled devices makes it difficult to usurp information. Other features such as internet access capability, secure information sharing capability, unique user identification, increased mobile phones computing power, convenience and budget control are some of the numerous advantages the NFC technology offers.

It comes in various forms such as stickers, wristbands, labels, key fobs, cards, inlays, and many more to mention but a few. It has an embedded microchips and aerials which can store a small amount of information for transfer to another NFC device, such as a mobile phone. Due to its limited memory capacity, an NFC tag is generally regarded as being a reference to data rather than a data store itself. For example, it is not feasible to store a website on an NFC tag, rather you store a web address or Uniform Resource Locator (URL) that would link the tag to a full website on the internet.

In this work, however, we propose an NFC-IoT solution to the challenge of manual examination process. An ID (Identity) was stored on the tag which then enables the system to identify the object and gain more information from the Cloud or other internet sources. As part of a university student management system, the NFC-IoT technology is only used in this work to simultaneously process the examination attendance registration and school fee verification system.

In a bid to improve students' attendance registration system, many researchers have adopted various technologies on different standpoints to improve on the existing systems by either developing standalone or web-based applications. Authors in [5], [6] proposed a campus access management system based on Radio Frequency Identification (RFID) technology. The data from RFID reader is transmitted to a centralized remote computer or server located in the administrative office of the institution through a RS-232 serial communication interface. The centralized server determines the authorization and access control rights. Access codes are entered through a keypad. The use of RFID technology makes it easy for multiple tags to be read at once. However, this technology is susceptible to tag and reader collision. Modifications can be made by using an NFC technology, a subset of RFID with closer read range, which is not susceptible to tag collision due to its ability to read only one tag at a time. It also offers better secure data communication.

In [7] a desktop-base application which has all the list of registered students for a particular course displayed when the lecturer starts the application was proposed. The attendance registration is done by clicking a check box next to the name of students that are present, and then a register button is clicked to mark their presence. Another similar project was proposed, but in this case the student

would have to register individually using client server socket program from their device -laptop [8]. In both works, there was an improvement on the manual process since attendance data can be stored safely and reports can be easily generated. Also, registering the attendance by proxy is eliminated in the first project since the lecturer will see each and every student in the class, while in the latter case students' snapshots are taken by the client application. However, both projects waste much time in the process of taking attendance. Modification can be made on the first system by adding a sensor or a biometrics system in the form of fingerprint that on sensing the student's Identity (ID), marks or checks the button automatically without human clicking so as to avoid parallax error.

Authors in [9] proposed a microcontroller-based attendance system with fingerprint sensor. The system contains two units or sections: a handheld device unit and a personal system unit. The handheld unit has devices such as fingerprint module, Real Time Clock (RTC), buttons, Graphic Liquid Crystal Display (GLCD), and PIC18F4550 microcontroller all forming integration on the system. The system allows students to mark their presence by placing their fingers on the device's sensor. Then the already registered students' information contained in the database system is displayed on the personal computer and the GLCD system for verification of students' identity, and registration of attendance in real-time. The design is seemingly efficient but further improvement can made by adding an authentication mechanism like password and other technologies such as RFID, NFC to avoid some drudgery associated with the fingerprint technology such as time wastage (time taken to reposition the fingers for proper capture and/or cleaning in case of a wet finger or dusty fingerprint scanner), false reading (failure reading the authorized person), cost effectiveness, less secure (prone to fingerprint recognition software by hackers making it foolproof), etc.

The authors in [10] described a case study that explores the adoption of attendance control system in the primary school environment. The system was implemented using networked technology components, including smart cards; NFC enabled mobile phones and card readers, a web portal, and short message service (SMS). Using Schwartz's value model adopted from social psychology as a framework, the study analyzed the technology adoption from the viewpoint of three end user groups namely: children, parents and teachers. The system has a feedback mechanism to notify parents or guardian of information regarding the arrival and departure of their wards to school in real-time either through SMS or online. The results of the study show that the adoption of such system brings positive experience to the end-user groups (i.e., children's parents and teachers). However, it is expensive to implement as NFC based android phones are expensive to afford for a large number of primary school students. Besides, these students are minor and rough so they could misplace their NFC card or phone. The phone could also serve as a source of distraction to these students.

Furthermore, NFC has been applied by several researchers in the educational sector to design automated attendance monitoring systems [7], [11], [12]. Authors in [13] proposed a mobile based university attendance management system to overcome the challenges of manual calling of students names in class and the issues of impersonation. The proposed system was tested during lectures and was found to be efficient in checking against false data and data entry errors.

2. Materials and Methods

2.1 Materials

The resources used in achieving this project are grouped into two broad categories: hardware tools and software development tools. The following materials selected for the implementation of the proposed system are discussed under the Software and Hardware sections:

2.1.1 The Hardware Components

The hardware devices interfaced to develop the system are discussed as follows:

The ATmega-328 Microcontroller: The ATmega-328 Microcontroller is basically an Advanced Virtual RISC (Reduced Instruction Set Computer; AVR) micro-controller deployed in this system for data processing and intelligent operations.

PN532 module is a radio frequency module with an integrated chip built around the Philip semiconductor **PN532** and used for remote communication at 13. 56MHz.This device can perform a read/write operation. However, it is only used in this work to read the unique identity (UID) or content of the NFC tags placed near it.

NFC tag is a wireless technology which allows the transfer of data between two NFC enabled devices. In this project, it stores a unique identity (UID) that references students' data that is contained in the database. **Java:** is the programming language of choice selected for developing the desktop application subsystem in this work because it supports the creation of cross-platform applications and provides the necessary Application Programming Interface (API) needed in the system implementation.

2.1.2 The Software Components

The software development tools used for this work are discussed as follows:

NetBeans: This is an IDE for developing various kinds of applications and mostly programs written in Java language. In this project work, it is used for writing and editing the source code.

MariaDB: This is a relational Database Management System (DBMS) used for data and information storage. It provides a matching support and functionality for MySQL Application Programming Interface (API) and commands.

HTML (Hypertext Mark-up Language): Since the proposed system consists of a web-based platform for tasks such as online registration of students and bank payments, the HTML was chosen for creating web pages and web applications.

PHP (Hypertext Preprocessor): This is a server-side scripting language designed primarily for web development and also used as a general-purpose programming language. This programming language was chosen for the development of the Application Programming Interface (API) which serves as an intermediary between the desktop application and the web server; it was also used in developing the server-side of the web application subsystem.

JavaFX Framework: This is a software platform for creating and delivering desktop applications, as well as Rich Internet Applications (RIAs) that can run across a wide variety of devices.

Bootstrap: This is a free and open-source front-end framework selected for designing the system web application.

JavaScript: is a widely used client-side scripting language on the web. It is deployed in this work to achieve the client-side execution of tasks in the advanced student management system

2.2 Method

This project employs the waterfall model in the analysis, design and development of NFC-based university student examination management system. The waterfall model is used as it helps in breaking down the development process into series of steps. It forms a choice of methods in the system implementation because of its sequential design process and applicability in the novelty of the NFC technology. Here, the hardware design is facilitated from the system block diagram. Subsequently, the software driver is implemented. Both are integrated while the testing, debugging and final implementations were concluded. Figure 1 represents a flow chart showing how the various modules of the subsystem form integration.

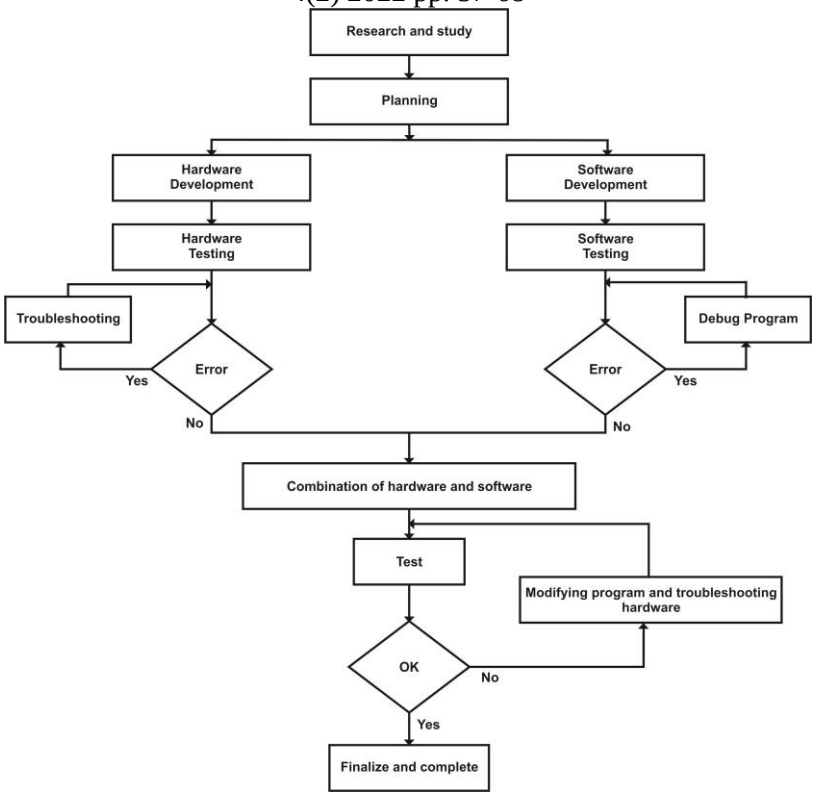

Figure1: Development flowchart

2.3 System Description

This section covers the hardware and software development. It describes the system block diagram, system schematics and software application processes.

2.3.1 System Block Diagram and Description

Figure 2 illustrates the block diagram of the NFC-IoT-based university student examination management system. This management system admits a student into the examination room only on grounds of school fee payment and then records the student's data automatically for examination attendance and eligibility. The systems and subsystems are connected to give a clearer picture of how the various parts of the system functions.

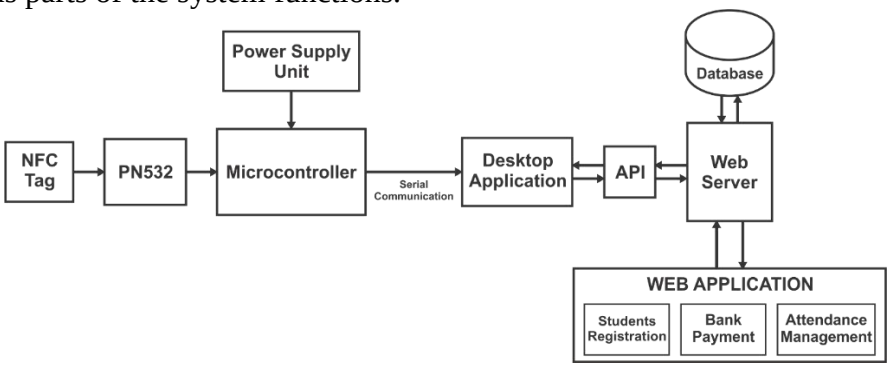

Figure 2: System Block Diagram

The entire system is triggered when the NFC Card which has unique identification number is brought into close proximity (5cm) with the NFC reader or scanner (PN532). The reader generates an electromagnetic field which causes electrons to move through the tag's antenna and subsequently power the chip embedded in the NFC card. The card which is a passive card (has no power source

of its own), is powered wirelessly by radio waves emitted from the reader/scanner (PN532). The powered chip inside the NFC card then responds by sending its stored data back to the reader in the form of another radio signal. The radio signal is interpreted by the reader which sends the data out to the ATmega328 microcontroller. The interpreted radio signal (data: identification number) is relayed serially to the desktop application which communicates the data to the web server through an Application Programming Interface (API). The unique identification number is used to query the database to obtain information about whether a student has paid his/her school fees. The results of the query are sent to the desktop application through the API; these results are then displayed through the graphical user interface of the desktop application. If a student is verified to have paid his school fees, his/her name and registration number are automatically added to an attendance list which validates their eligibility in writing the examination. This attendance list can then be printed by the administrator using a provided web application on request. The web application also provides platforms for students' registration and instant payment in real-time.

2.3.2 System Schematic Diagram and Description

The hardware design, as depicted in Figure 3, is integrated with NFC tag, PN532 (the NFC reader), ATmega328 microcontroller, Max232, DB9connector and Personal Computer (PC). The system works by interfacing these devices to the microcontroller such that when an NFC tag, containing unique student id, is brought near a PN532 reader the device picks the signal in form of electromagnetic wave and relays the data to the microcontroller which in turn decodes and acts on it based on the micro-program on it before sending it to the PC serially through a voltage level shifter (max232) and a serial converter (DB9 converter) which act as interface between the microcontroller and the computer system. The PC which serves as a local host with database saved on its local disk then launches an application developed in Java programming language to verify the authenticity of the bearer as well as add the student's details in attendance list and make them eligible for examination hall admittance.

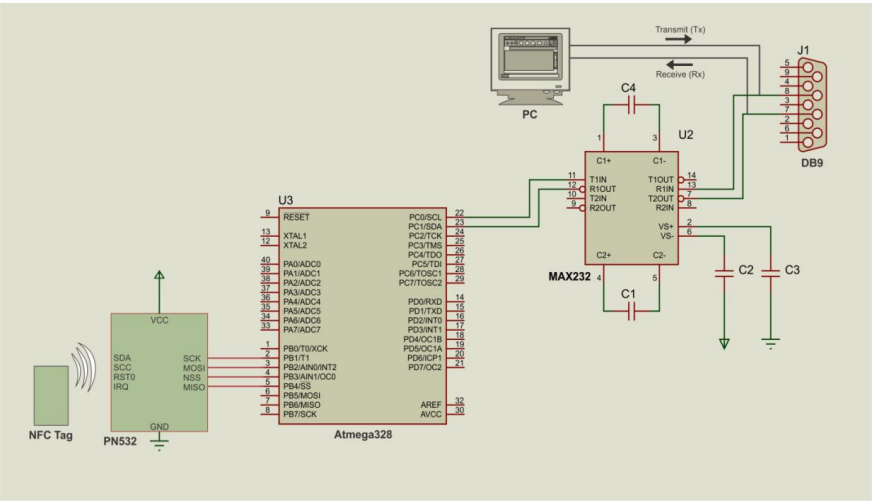

Figure3: Schematic Diagram of the System Design.

2.3.3 System Software Module Description

The software development involves the development of algorithms and their implementation using Java programming language with NetBeans as the selected Integrated Development Environment (IDE). During software development, a system design was made which comprises the input, output, process and database design. These concepts are explained in this section:

Input Design: This deals with how data is fed into the software subsystem. Inputs into the software system are sourced electronically from the database and NFC interface. Users' inputs are captured using the keyboard and mouse and is designed using Graphical User Interface (GUI) input controls or widgets such as textboxes, radio buttons combo boxes and labels. A simple input design for administrator login is shown in Figure 4.

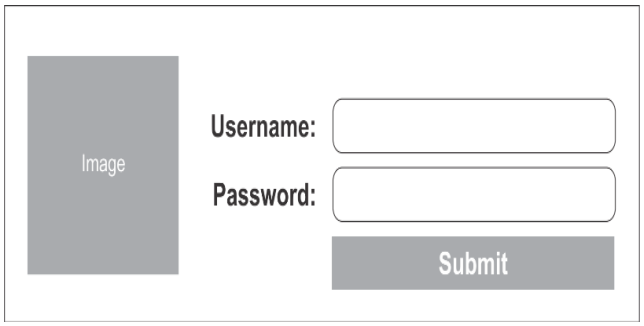

Figure 4: Sample Input Design

Output Design: System interface is designed using JavaFx framework, a Java library or software for creating and executing desktop applications, and rich Internet applications (RIAs) that can run across multiple platforms. Outputs contain the result of the processed inputs; they are what the user sees on the screen. These outputs are displayed through the interface, which are interactive with the user.

Process Design: The software process design plays an important role in the implementation of the software subsystem. It helps to understand the working procedure and process design of the system. The flow chart of the software subsystem is shown in Figure 5.

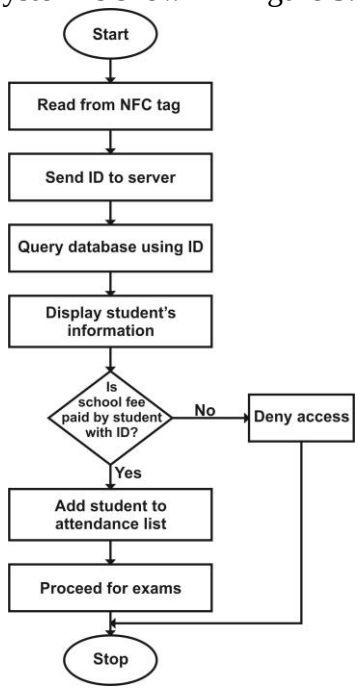

Figure 5: Student Admittance Flowchart

2.3.4 System Integration

This section explains the integration of the hardware and software development. First, a comprehensive literature review on the subject matter was carried out in order to know the state of the art of the subject. Based on this, the problem is formulated; the objective and scope of the project have been defined. The next phase is planning and organization of the project or problem formulated

followed by systematic arrangement of possible solution. The work is then divided into two parts: Hardware design and Software development. The proteus8.6 software has been chosen for the circuit design while the PN532 NFC Reader module is connected to the ATMEGA 328 microcontroller in Serial Peripheral Interface (SPI) with coding in C and Java languages. The final circuit design is then implemented on a Vero board and unit test is performed to ensure it is error free. Finally, functional and non-functional testing procedures are carried out on the system to free it from bugs and malfunction.

3.0 Result and Discussion

After appropriate design, implementation and testing, the system proved to be an efficient, functional and a reliable NFC-based school admittance system. The system operated properly and adequately thereby meeting the minimum expectations that was needed initially. It is expected to be beneficial to high institutions with the need to computerize and automate student attendance registration and fee verification system. The result of this work which is formed from the integration of these subsystems such as a web application, desktop application and a microcontroller-based NFC reader are described in this section.

3.1 Web Application

The web application, which is developed using PHP programming language, provides a platform for student registration and administrator operation such as viewing and editing of students' records, viewing and printing of attendance list; and resetting the system in preparation for a new session. For the purpose of avoiding unauthorized access to the administrator area, the system provides an administrator login page for access authentication. PHP provides various cryptographic operations: Hash functions such as MD2, MD5 and SHA-1; asymmetric encryption such as RSA; and symmetric encryption such as Advance Encryption Standard (AES), DES, triple DES, etc. In this work, MD5, SHA-1 and AES are used. Screenshots of the graphical user interfaces are presented in the Figures 6 - 9.

Student Registration Page: On this page, the student supplies the required details for registration and by clicking on the submit button, this information is stored on the MariaDB database. Information like the passwords is secured using a cryptographic hash function (SHA1) before storing them in the database. During registration, student will need to upload a profile picture as shown in Figure 6.

Administrator Login Page: This page is incorporated to prevent unauthorized access into the administrator area. As shown in Figure 7, the administrator needs to supply a username and password to get access into the system.

Attendance List Page: This page enables the administrator to view attendance of various exams taken in the institution. By selecting the course code, entering the year of examination and clicking the proceed button, a list of the student who took an examination is displayed

Student Edit Page: Figure 8 shows how the student details can be edited or modified on this page. Clicking the submit button updates the students record with the new information.

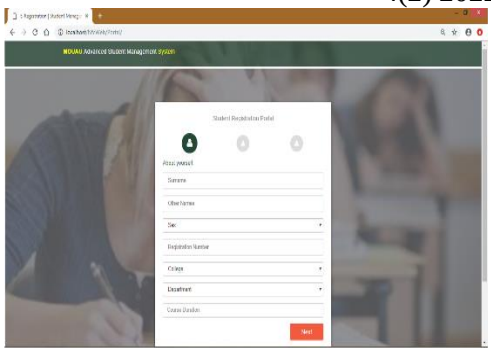

Figure 6: Student Registration Page

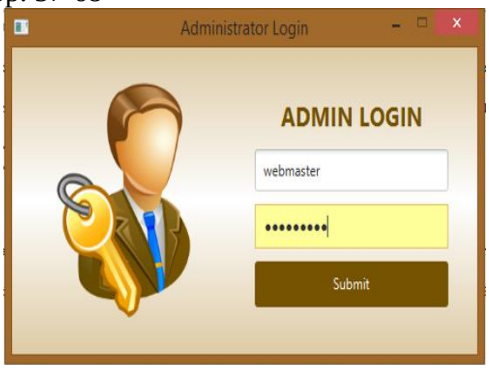

Figure 7: Admin Login page

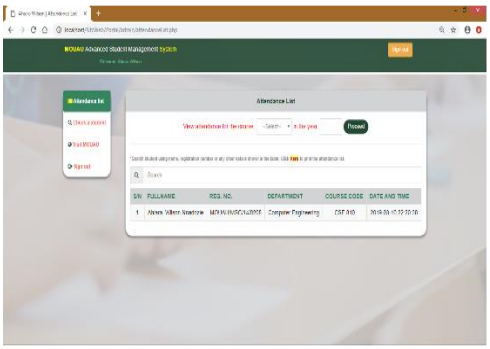

Figure 8: Attendance List Page (Admin Area)

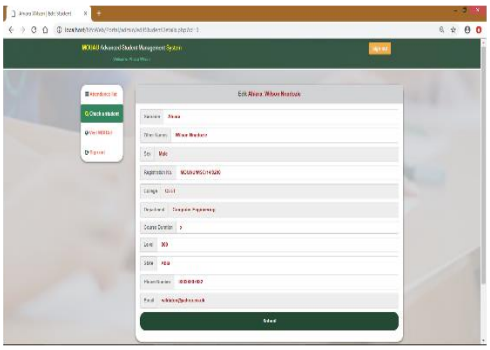

Figure 9: Student Edit Page (Admin Area)

3.2 Desktop Application

The desktop application developed using Java programming language and only accessed by an authorized administrator, performs the core function in this project work which is to admit eligible student into the examination hall. Another function is to update students' record with a captured UID registration. To avoid unauthorized access to the functionalities of the system, the system provides a login window for authentication of administrators. This application interacts with the server through an Application Programming Interface (API) developed using PHP scripting language. Figures 10 - 14 presents the results obtained from the desktop application on implementation.

UID Registration-Login Window: Before a UID can be registered, the administrator needs to login the student with the UID containing tag. If the correct login details are provided, the server returns a 'success' response which opens the UID registration page.

Figure 10: UID Registration-Login Window

UID Registration Window: This window displays some information about the student whose details is about to be updated with a UID. From Figure 11, clicking the 'start UID capture' will activate an event listener that checks if data (UID) is available through the serial port. When a UID is successfully captured, it is displayed in the text field just below the 'start UID capture' button. Note that some characters in UID text are hidden and replaced with the character 'x' as shown in Figure 12.

Admittance Window: To open the Student Admittance window, click on file on the menu bar and select Admittance. This displays input dialog boxes for entering the course title and course code after which the student admittance window is presented. When opened, this window continuously checks the availability of data (UID) from the serial port. On the hardware system, when a tag is placed in close proximity to the NFC reader, the tag UID is captured and sent to this application through the serial interface. On receiving the UID, the application communicates with the server and gets a response. Based on the response, the GUI components are updated with the necessary information. The Figure 13 shows a student who has paid his tuition fee and will be allowed to partake in the examination. With the help of the API, students who paid their tuition fee are automatically added to the attendance list which can be printed by the administrator from the web application interface developed in this project. When a student with the captured UID is not found, the window in Figure 14 is displayed.

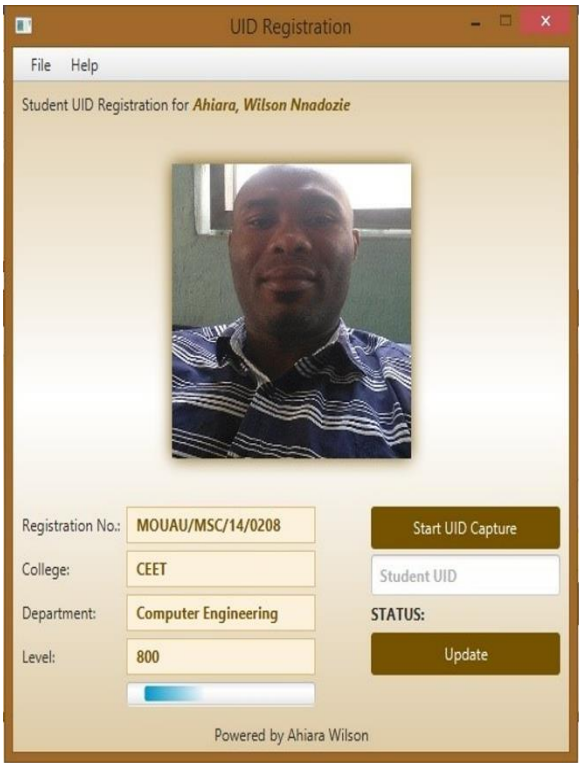

Figure 11: UID Registration Window (UID not captured)

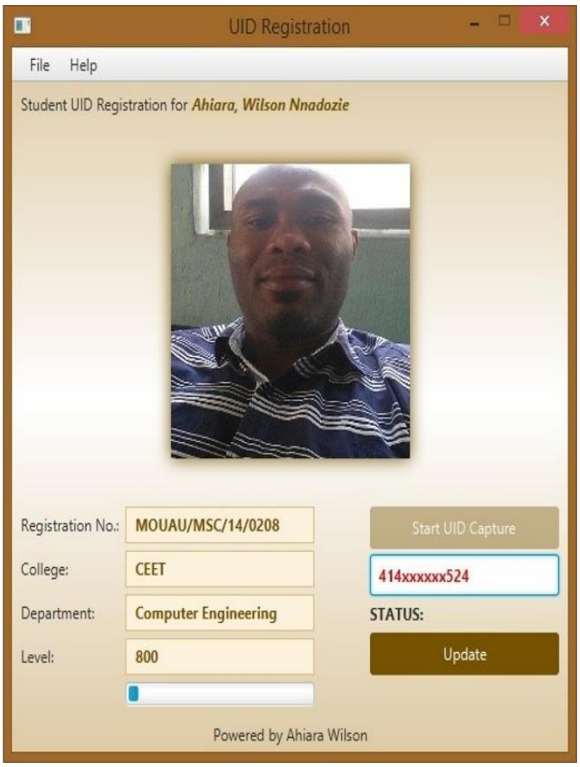

Figure 12: UID Registration Window (UID captured)

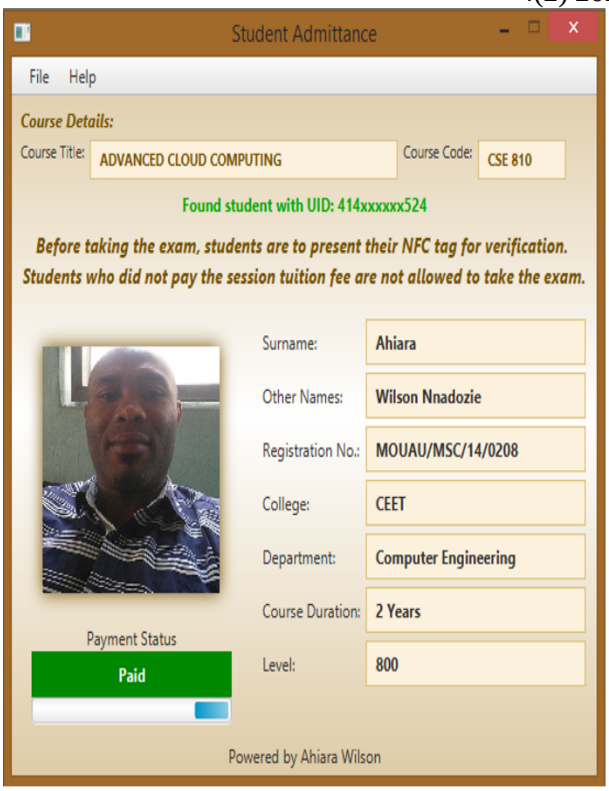

Figure 13: Admittance Window (UID captured, student found with fees paid)

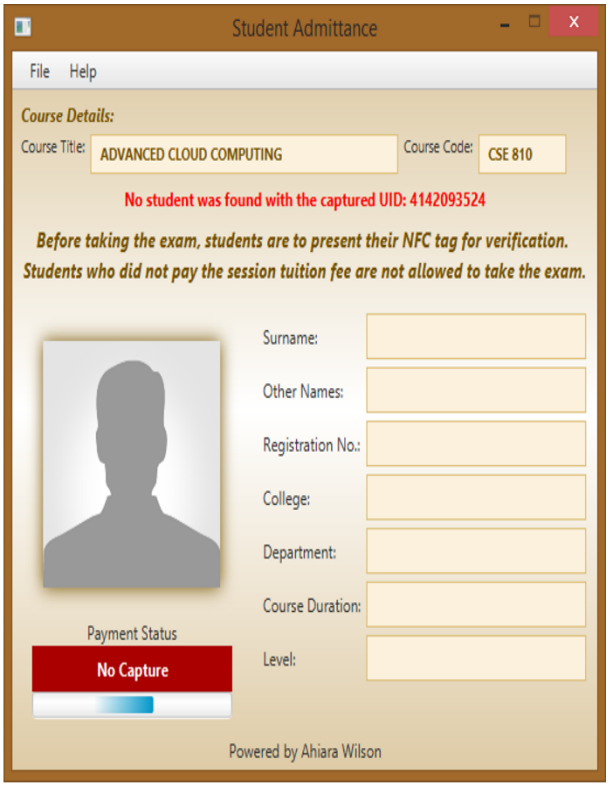

Figure 14: Admittance Window (UID captured, student not found)

3.3 Analysis

This section presents the analysis of the transmission time, processing time and transaction time. The transmission time is the amount of time it takes for the captured UID to be transmitted from the serial port to the Java application while the processing time is the total amount of time it takes the Java application from relaying the captured UID to the web server to displaying relevant information about a student. The transaction time is the sum of the transmission and processing time. Table 3 shows the transmission, processing and transaction time of seven UID captures.

Table 3: Transaction time for various UID captures

S/N	Transmission time	Processing time	Transaction time
1	1	56	57
2	0	19	19
3	1	180	181
4	0	102	102
5	0	35	35
6	1	32	33
7	0	40	40

From observation, the processing time for registered UID of a student who has paid his/her tuition fee is high compared to that of a registered UID of a student who has not paid his/her fee. This high processing time could be attributed to the time taken to add the student to the attendance list. The processing time of an unregistered UID is the lowest. The proposed system shows better processing time performance compared to the work of Daramola et al [13].

4. Conclusion

In recent years, Near Field Communication has become one of the promising technological developments in information technology industry due to its exploding growth and ubiquitous use in various fields to aid man in his work. A brief review of NFC technology made in this work would, without doubt, enhance understanding of its functionality and launch it into the broader context of existing technologies that can be integrated into our university system to make the task of university management easier as well as sustain the advancement of knowledge in NFC application in order to promote user acceptance, usability, reliability, and other NFC capabilities.

The adoption of the NFC-IoT technology in the design of an improved university student examination management system has really proven to be reliable, secure, flexible, cost effective and simple in comparison to the work in [13]. The system presented in this work is better than the traditional system. It simplifies and automates the manual system of attendance registration and school fees verification process, cuts down the delay tactics in manual attendance taking, prevents proxy attendance registration, impersonation in an examination, forged school fee receipt and truancy in examination hall. One of the major unique features of this proposed work is the exclusion of NFC enabled mobile phone in the design to save cost, improve security of data transfer, discourage and eliminate the need or use of a mobile phone in the examination hall or room for verification. This initiative is in tandem with University's examination offenses of bringing into the examination hall any incriminating materials or gadgets such as mobile phone.

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