Development of Secure RFID Authentication System for Electronic Inter-Campus Transportation Billing

By

Kolo, J. G., Dogo, E. M., Olaniyi, O. M., and Oyegbemi, S. A.
Department of Computer Engineering,
Federal University of Technology Minna,
Niger State Nigeria
Email: eustace.dogo@futminna.edu.ng

ABSTRACT

A good transportation system is an essential recipe to the economy of every city. This work made attempts to improve the transportation billing system by automating the process using RFID technology, devoid of physical cash collection. Inter-campus University transportation service is taken as a case study. Secure RFID reader and tag was used, employing an AES encryption scheme for authentication, where users register with their student identification card which is their unique RFID tags and credit their account in preparation for future travel. The prototype system is developed to place on hold a faulty vehicle while making suggestions for vehicles that are available for travels. The system also saves the record of each travel with respect to the time and destination of the vehicle. Accuracy and response time were metrics used to evaluate the performance of the implemented prototype system; the accuracy of the system when tested on fifteen (15) different users is 100%, while the system has an average response time of 0.29 seconds.

Keywords: Radio Frequency Identification (RFID); Advance Encryption Standard (AES); Billing system; Feature Driven Development; Transportation.

INTRODUCTION

Transportation is the movement of people, goods, and services from one location to another (Bukohwo & Ature, 2014). Hence, transportation has remained an irreplaceable tool for proper development and functioning of any city (Solanke, 2013). There are two basic ways of carrying out this movement, either by private means, i.e. the use of personal vehicles or public transportation services. In a country such as Nigeria, the population is growing due to an increased ratio of maternity to the mortality rate as well as rural to urban migration for work, studies or other business activities. Therefore, the need for more attention towards public transportation service which has drastically increased in recent time, because it helps to reduce the occurrence of traffic congestion (Bukohwo & Ature, 2014). Public means of transportation is often also seen to be cost-effective compared to the private means. Nevertheless, most public transportation services make use of cash payment while a few use the paper ticketing for billing of passenger fare. This method of payment has posed serious problems to the public transportation services and as well the commuters. Such problems include littering of the environment by paper tickets after being used for travel, irregular transportation billing, and possible payments insincerity by engaged operators and unfair increase in transportation fare by the individual public transporter. The managements of each public transportation service have also been affected, most especially when the service is not being monitored by the owner, since the attendant in charge of the billing may not remit all the money that has been generated to the organization's account. This shows that manual transportation billing system also encourages fraud and mismanagement. Hence, more attention has been directed to the automation of the bus transportation management system (Mithlesh, 2013). The manual transportation billing scheme is currently in place in most Nigerian University campus transportation services. Hence, automation of existing manual transportation service against irregular transportation billing, mismanagement as well as an unfair increase in transportation fare becomes necessary, especially in multi-campus transportation scenario.

Currently, students of the Federal University of Technology Minna are faced with numerous challenges daily because of the manual transportation billing system, such as overcrowded and queuing process at the bus park due to manual cash transactions and as a result, causes delays and lateness to class. In this work, the student identification card which is embedded with RFID tag and owned by all registered students who are the prospective passengers and is used, thereby eliminating the need for procurement of separate RFID tags. The identification card also has unique information about each student. Some advantages of RFID based ticketing system over existing manual system (both paper-based tickets & manual payment by cash) are using automatic ticket systems allows operators such as transportation authorities to save time and management costs; transport fee collection can be much more efficiently organized. These systems require low maintenance costs, which represent a further advantage (Chandra, Keshari, & Soni, 2014). Furthermore, the integration of relational database model in the context of data management of electronic transportation services could alleviate inherent challenges in manual transportation services. This work applied MYSQL relational database management system to save information of individual passenger who has been registered, this information includes: name, matriculation number, student id number, department, balance and travel history, for a simplified transportation data representation and easier expression of complex queries from the database. The remaining section of the paper is organized into four sections: section 2 look at the review of related work, section 3 address the materials and method used to develop the prototype system, section 4 discusses the result obtained after the prototype has been deployed and section 5 gives a conclusion and future work.

REVIEW OF RELATED WORKS

In the past few years, RFID technology has been widely applied to public transport for ticketing and billing. A series of works have been published in this research direction.

(Chandra, Keshari, & Soni, 2014), made use of the RFID in the automation of the transportation management system. The system was designed such that each bus has two RFID tags attached to the front door to inform the reader of the departure of bus and rear door to inform the reader of the arrival of the bus. The reader is connected to the main server for the purpose of ticket billing. All the passengers have a prepaid RFID based card that possesses a unique identification number. The major drawback of the work was that the authentication security of the system was not adequately considered and no prototype implementation to evaluate the system.

(Kalal, Bisht, Tikar, Yatnalkar, & Chaware, 2014) uses a "Tap-&-Pay" procedure, where the user taps the card on the reader, and then after there is a successful exchange of packets through sockets, the database values are matched with values on a RFID tag, the card is thereby recognized and the client-server communication is processed. The fare calculation class was implemented to execute the transport billing, with that, the amount to be paid by the user is determined by the system and finally, the transaction is completed. The system was a proposed idea with no prototype implementation to demonstrate the feasibility of the solution.

In (Mor, Sharma, & Sodhi, 2014) the authors developed a transport management system using RFID hardware system and an application developed in VB.Net to provide a graphical user interface (GUI). Two Caesar cipher encryption algorithm was used with different keys to address security issue by encrypting and decrypting information between the reader and database when the tag communicated with the reader. But the study lacked an overall performance of evaluation of the entire system in terms of speed and accuracy. Security of RFID billing system remains a concern (Peng & Bao, 2010) and billing for e-ticketing in public transportation systems in general (Kerschbaum, Lim, & Gudymenko), mostly due to RFID limited computational capabilities to fully implement AES (Peris-Lopez, Hernandez-Castro, Tapiador, & Ribagorda). This work is, therefore, an improvement of the work done by (Mor, Sharma, & Sodhi, 2014).

MATERIALS AND METHOD

This work consists of both hardware and software parts integrated together. The hardware component of this system consists of the Arduino board, RFID reader and tags, Wi-Fi shield, six (6) LEDs and four (4) toggle buttons.

System Hardware Design Consideration

The hardware module requires a microcontroller unit to coordinate the other part of the hardware and ensure that they function together synchronously. The Arduino Uno is a microcontroller board that has been designed based on the ATmega326 microcontroller is used for this system. The datasheet configuration of the board is as follows:

i. 14 digital I/O pins (6 of which provides PWM output).
ii. 32KB flash memory (of which 0.5KB is used by the boot-loader).
iii. SRAM of 2KB.
iv. EEPROM of 1KB.
v. 16 MH clock speed.
vi. Recommended input Voltage of 7-12V.
vii. Limit of input voltage 6-20V.
viii. DC current per I/O pin of 40mA.

The RFID module consists of a reader and a tag. The receiver (reader) is a device which gets information from the transceiver (tag). This is done by detecting the frequency of the unique tag that was brought close to it. The tag sends the information to the reader and the reader communicates to the Arduino board with the value read from the tag.

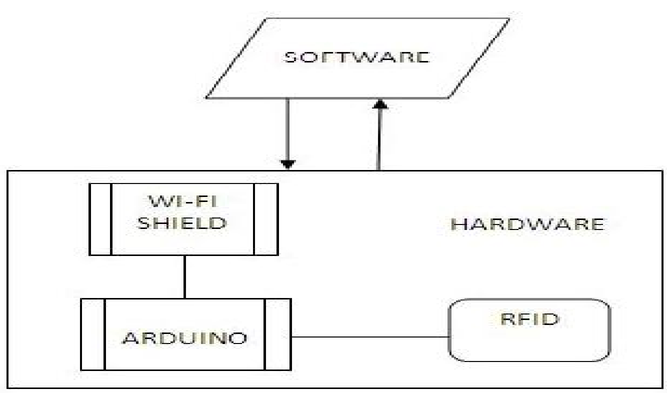

Figure 1: Block Diagram of the System

Figure 1 shows the block diagram of the system, which comprises the hardware and software components.

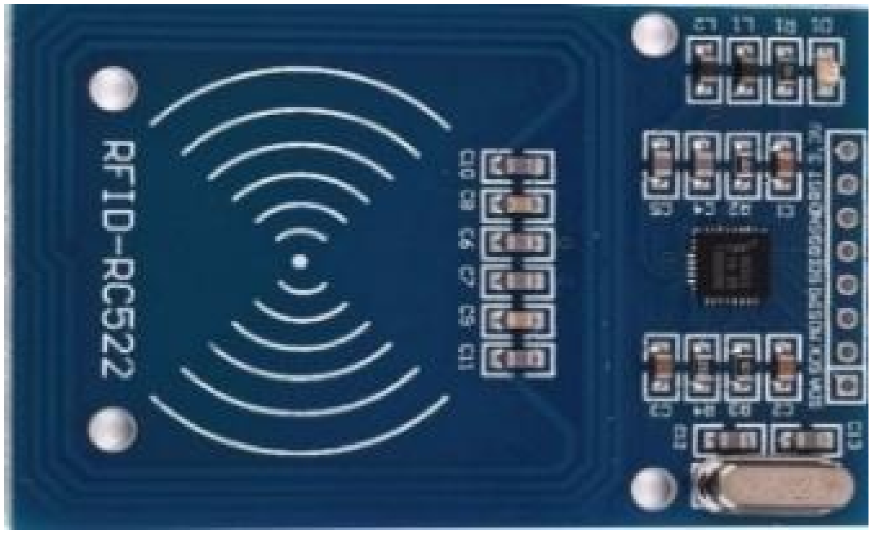

Figure 2: RFID Reader (Robomart, 2015)

Figure 2 shows the RC522 RFID reader while Figure 3 shows the passive RFID tag with a frequency of 13.56MHz that are used in this work.

Figure 3: Sample ID RFID Tag

RFID Fundamental Communication Theory

A passive tag is used in this work, this is the type of RFID which acts as an antenna, has a semiconductor chip attached to the antenna, and uses an encapsulation technique. Unlike the active RFID tag, passive tags do not have their own power source. The tag reader provides the tag with the necessary power needed for its communication with a tag. The RC522 RFID reader operates at a frequency of 13.56 MHz; hence the tag used also communicates at that frequency.

The method of communication between the transceiver and the receiver is based on the principle of electromagnetism. There are two basic regions in this transmission process which are the far field and the near field. The far field is the region where the electromagnetic field and the antenna are separated from each other and the field propagates in free space as a plane wave. There exists a constant ratio between the electric field (E) and magnetic field (H), this constant is approximately 377Ω. The distance where the far field occurs may be approximated for a small antenna where D << λ as:

$$r_{nf} = \frac{\lambda}{2\pi} \quad \ldots \quad (1)$$

Where λ is the wavelength of the transmitting tag, D is the maximum dimension of the radiating tag and r_{nf} is the distance from the antenna in the near field. Nevertheless, the far field distance in which D > λ. Equation 1 reduces to:

$$r_{ff} = \frac{2D^2}{\lambda} \quad \ldots \quad (2)$$

Where r_{ff} is the distance from the antenna in the far field. Hence it can be inferred that the transition region (r) is the region between the reactive near field and the far field as given by the equation 3:

$$\frac{\lambda}{2\pi} < r < \frac{2D^2}{\lambda} \quad \ldots \quad (3)$$

Since this work makes use of the passive tag which does not have a power of its own, there exists a relationship between the power transfer to tag (P_T), power on the reader (P_R), the reader antenna gains (G_R), tag antenna gain (G_T), and the electric field strength of the reader at a particular tag position (E). First, there is a need to establish the relationship between the power transfer to the tag and tag antenna gain given by equation 4.

$$P_T = \left(\frac{E^2}{120\pi}\right)\left(\frac{\lambda^2}{4\pi}\right) G_T \quad \ldots \quad (4)$$

Also, the relationship between the reader power and the gain of the reader is given by:

$$P_R = \left(\frac{E^2}{120}\right)\left(\frac{r^2}{G_R}\right) \quad \ldots \quad (5)$$

Therefore,

$$\frac{E^2}{120} = \frac{P_R G_R}{4r^2} \quad \ldots \quad (6)$$

Substituting equation 6 into equation 4 gives:

$$P_T = \frac{P_R G_R \lambda^2 G_T}{(4\pi r)^2} \quad \ldots \quad (7)$$

Equation 7 shows the relationship between the RFID reader's powers, the power transmitted to the tag, the gain of the reader's antenna and the gain of the tag's antenna (Finkelzeller, 2008).

Furthermore, in this work, the hardware connects to the database wirelessly. There are two major technologies that can be used to achieve this, either the usage of ZigBee or the Wi-Fi technology. This work uses the Wi-Fi technology to achieve this objective. The choice of the Wi-Fi technology is due to its wide range and fast mode of data transmission since speed is also a factor to be considered in any engineering system.

The Wi-Fi shield is an electronic component that has most of its pin configuration almost equivalent to that of an Arduino UNO board and can provide any Arduino board with an internet connection using the IEEE 802.11 specification for Wi-Fi; it has the ability to connect to any wireless networks that work based on the 802.11b and 802.11g specifications.

System Software Design Consideration

The software design considerations basically include front-end design consideration and back-end design consideration. The front-end involves the development of web user interface application using hypertext preprocessor (PHP) programming language, a markup language known as the Hypertext Markup Language (HTML) and the cascading style sheet (CSS). PHP was used to provide a dynamic web interface and connectivity with the database while CSS is used for enhancing the application's appearance.

This work requires a database management system to store and retrieve data. The back-end was designed using MySQL database, due to its robustness and portability. The entities involved in this work include the traveler or passenger, system administrator, driver and the bus. Figure 4 shows the Entity Relationship (ER) diagram used for the system.

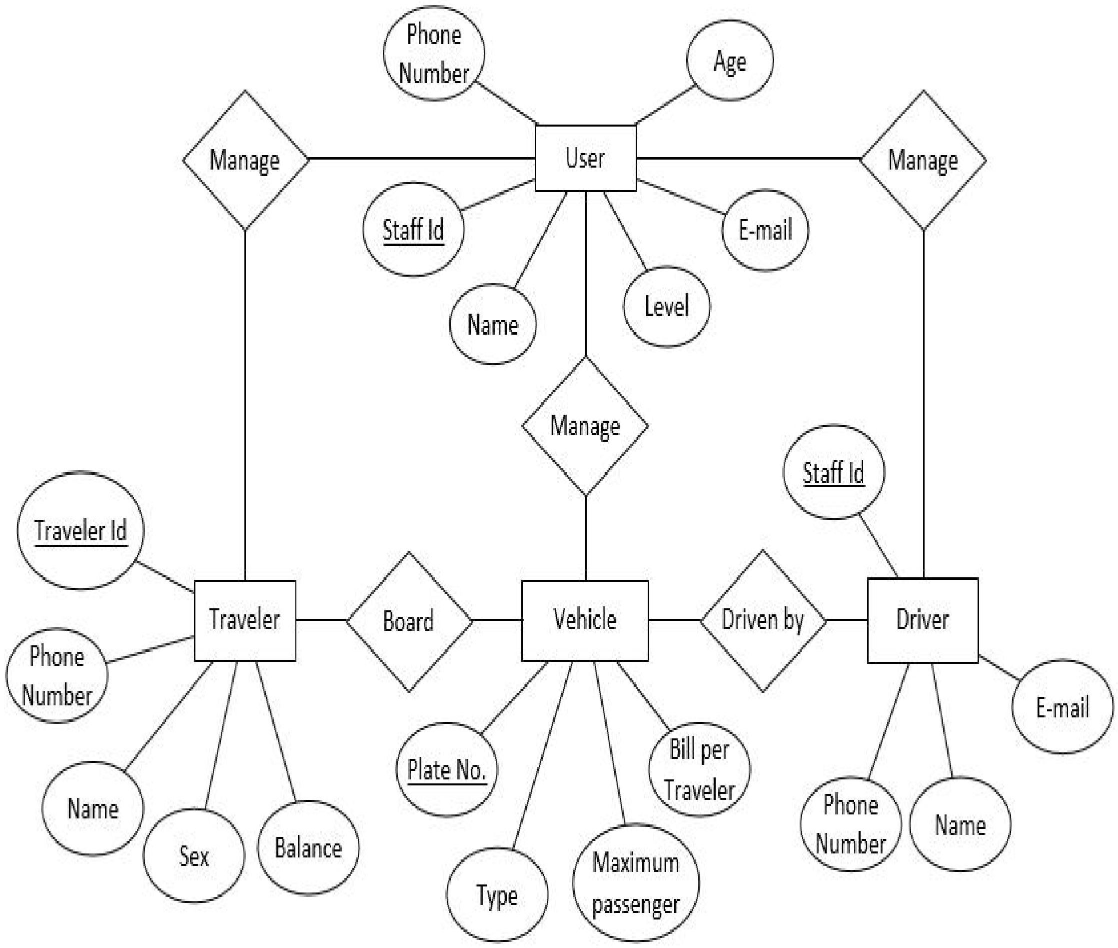

Figure 4: Entity Relationship Diagram

Agile software development (ASD) methodology was used in the software development process. The Agile software development is based on the iterative and evolutionary methods. This method does not focus effort on voluminous up-front design, analysis, rather on the development of small increments of functional code base on the immediate client requirement. There are varieties of agile software development which includes Extreme Programming (XP), Scrum, and Feature Driven Development (FDD). This work implements the FDD approach.

FDD is an iterative software development process approach which is model-driven with natural applicability in diverse problem domain areas. It starts with client and developers defining an overall model of the client's domain and then continue with design by feature and building features list by iteration (Palmer & Felsing, 2002). There are five basic components of the FDD process approach: building an overall model, build a feature list, plan by features, design, and development by feature as shown in Figure 5. FDD makes these processes easy to implement and agile in a given problem domain based on client requirements in a relatively comfortable time. With FDD, features are planned and developed one after another as incremental units with tangible result outputs which make it widely applied in software development process.

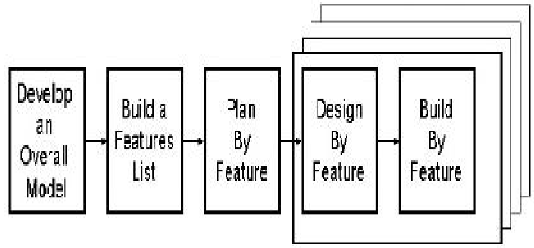

Figure 5: Feature Driven Development Approach Scheme (Palmer & Felsing, 2002)

An advanced encryption standard (AES) which is a standard for symmetric (private) key encryption is employed in this work to secure the developed software. The block size of AES describes the numbers of columns in the block; it can be of various sizes such as 128, 168, 192, 224, and 256 bits. The *Rijndael algorithm* begins with an addition of round key. To get the round key; six (6) is being added to the number of columns in the block (Nb).

AES-256 is used in this work, with Nbis been 14, hence the round key to be added is 6+14 = 20. This shows that the number of rounds required for AES-256 is 20. Each of the first nineteen (19) rounds consists of four (4) different steps which include: Substitute byte, shift rows, Mix columns and then add round key, whereas the twentieth (20) round only consists of three stages (i.e. the Mix column stage is omitted). All these stages are also done in decrypts of the ciphertext, but in the inverse direction of the encryption procedures. This implies that the decryption algorithm starts from the twentieth round which consists of three stages i.e. adds round key, inverse sub-byte, and inverse shift row, while round 19 down to 1 (i.e. 19 rounds) consist of four stages which include Inverse mix column, add round key, inverse sub-byte, an inverse shift row. Figure 6 shows the process flow diagram of the kind of the AES algorithm employed.

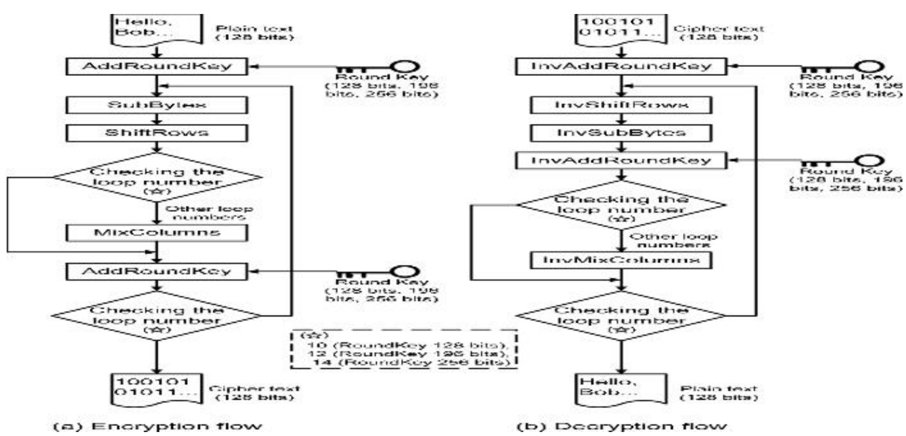

Figure 6: Process flow diagram of AES algorithm (Kumaki, Fujita, Nakanishi, & Ogura, 2013)

The front end of the application provides a GUI for system users (an admin and an attendant) to manage the information stored in the database (back-end). The database is used to save all registrations done by the system users and also to store information about passengers account balance, their travel history and trips made by all registered vehicles. Furthermore, there exists a RFID system which is used to read a unique tag of individual traveler or passenger both at the point of registration and travel. Figure 7 describes the overall system integration.

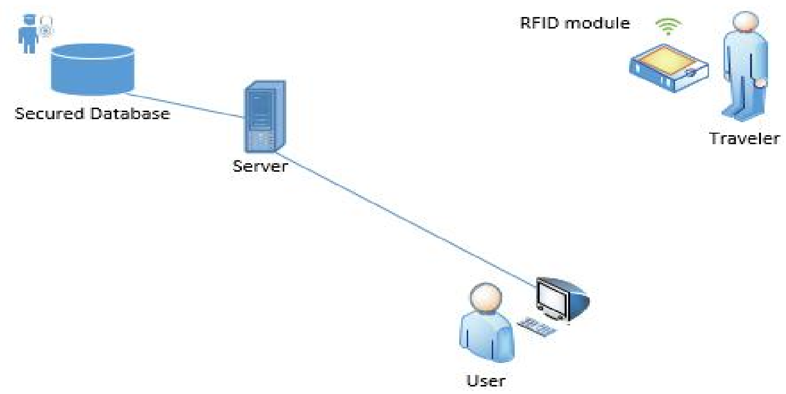

Figure 7: Overall System Integration

At the point of the passenger's registration, the reader communicates with the passenger's ID tag and sends the information to the database where it is stored. The attendant then selects the tag ID that has been read and saved to continue the registration process. When all required information about the passenger has been entered, the attendant then clicks on the save button, at this point the information is encrypted before sending to the database where it is saved and can be retrieved when required.

At the point of travel, the attendant selects the current location of the passenger, then the system searches through its record of buses, decrypts the information about the buses that are in good condition and starts to compare the current location of each of the retrieved bus to the location selected by the attendant. When the system finds a match, it puts the information of all the matching buses in an array and returns the array data to the attendant. The attendant can now select one of the vehicles retrieved for travel. Each bus is identified by its plate number which is part of the information being retrieved. When a specific bus is selected, the system then retrieves all the information about the particular bus that has been chosen to travel. This information includes the cost of travel per passenger and the maximum number of passengers the bus can carry. The passengers can then begin to board by swiping their tags on the RFID reader one after the other. Figure 8 shows the system flow chart at the point of travel.

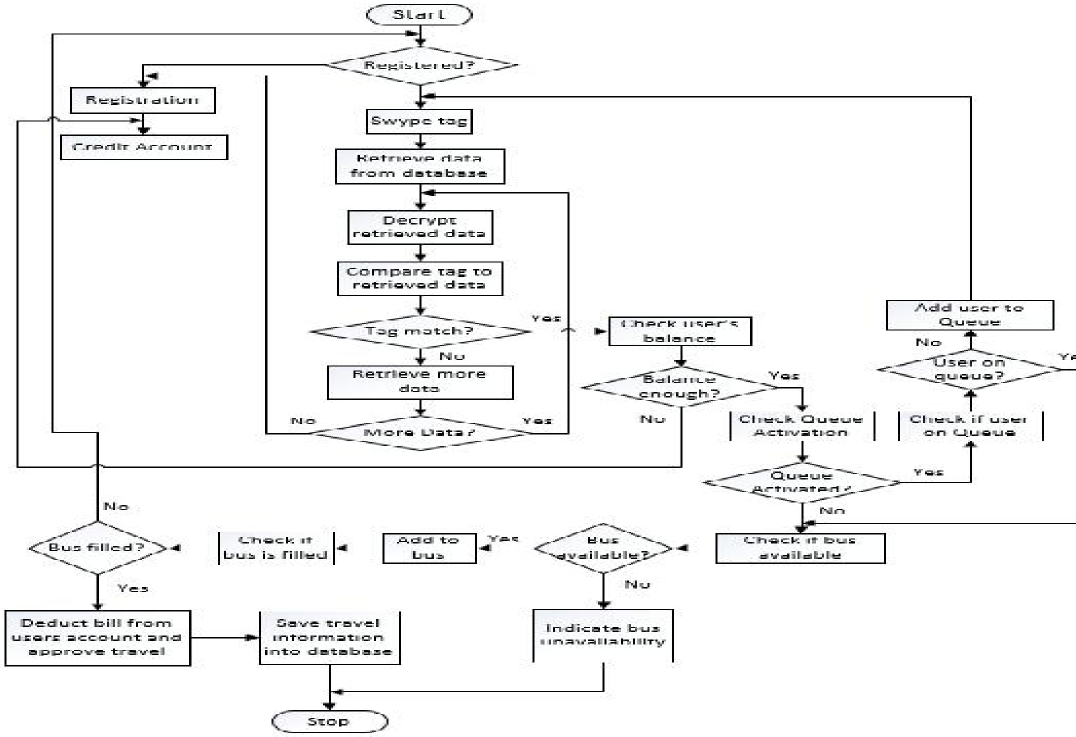

Figure 8: The System Flow Chart Diagram

The RFID reader reads the ID on the passenger's tag and sends it to the Arduino board for processing. The microcontroller on the board then sends the tag ID via a wireless network to the web for further processing. The web searches the database for information pertaining to the RFID tag number read. If the tag information exists in the database, then the system checks if the user has enough balance or not. If the user has enough balance, the passenger is added to the bus and permission to enter the bus will be granted by the attendant. This process continues as a loop until the total number of passengers that have been added to the bus equals the bus capacity, which is the maximum number of passengers that the bus can accommodate. When the bus is filled, the attendant can then approve the travel, and the bill is deducted from each of the passengers' accounts. The information about the travel is encrypted and then saved in the database. Figure 9 shows the overall circuit diagram.

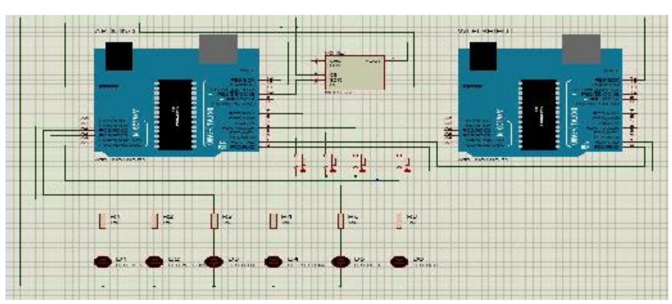

Figure 9: The Overall Circuit Diagram

RESULT AND DISCUSSION

Administrator and Attendant are two user profiles created on the system based on the permission and access right on the passengers' details. Both categories have the same login page which is shown in Figure 10.

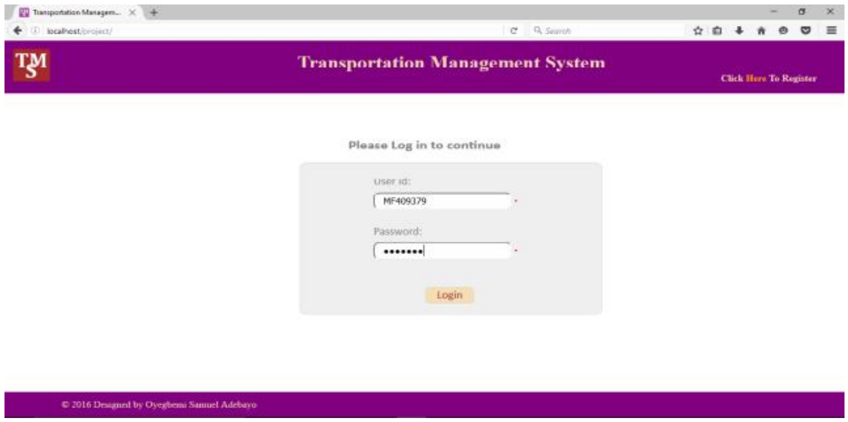

Figure 10: Login Page

The login page is an environment that makes provision for identification of each user with their username, and also authentication of identified users by their individual password. Since users are categorized according to their permission and access rights, then each category has its given privilege or access to the system, this is to achieve access control to the system resources i.e. passengers' details and other user's information. Hence, after a user enters a username or password, the system checks through its database if the username and password combination provided exists or not. If it exists, the system also checks if the user has been approved by a system administrator and assigned to a specific category of user profile. Therefore, the system only gives permission when the user exists, and has been assigned a user role, as an Attendant or an Administrator.

Users can register through the registration page, which provides them with an environment to input their details. Figure 11 shows the environment for user registration. After registration, the Administrator must confirm the user and the assigned role to the user. The registered user would not be able to login to the system if this approval has not been done

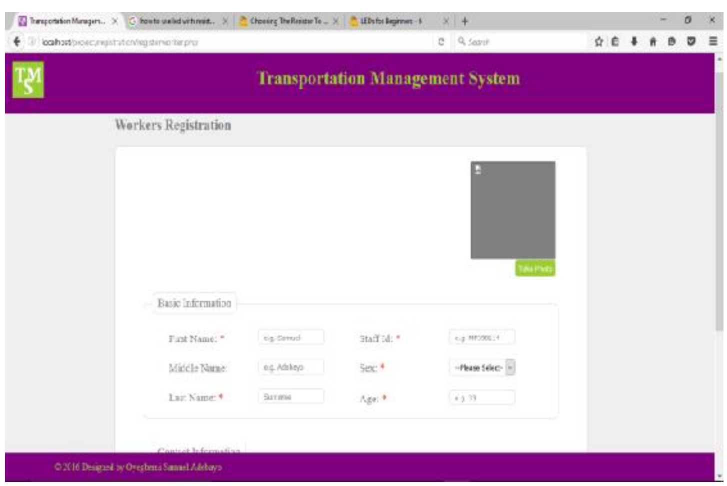

Figure 11: Registration Page

The attendant has the privilege of relating with the passenger, in terms of registering new passengers, crediting passengers' account and initiating and approving travels. Figure 12 shows the passenger's registration page administered by an attendant.

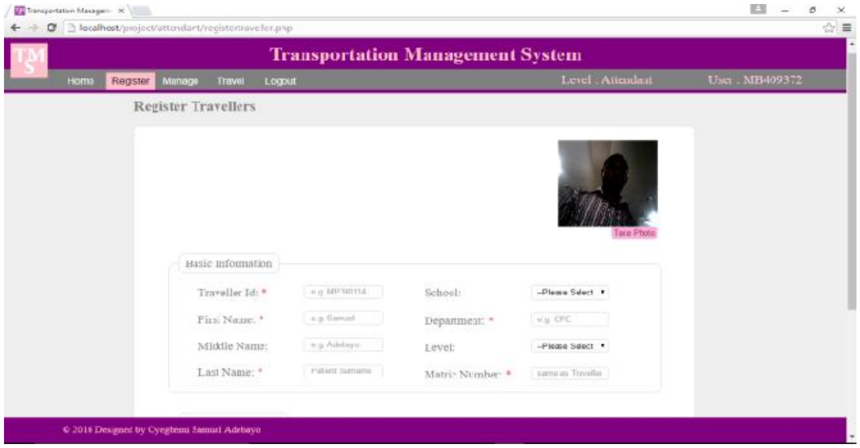

Figure 12: Passenger's Registration Page

After registration of passengers, each passenger must go to make a payment in the bank and submit the bank teller to an attendant. While making the payment in the bank, the depositor's name field of the teller will contain the passenger's student Id (or staff Id in case of staff). It is with this id that the attendant credit the passenger's account based on the amount deposited. Figure 13 shows the pop-up for the attendant to initiate the payment transaction.

After inserting the amount and teller number in the fields provided, another pop-up prompts the attendant to input password to confirm that the transaction has been performed by an authorize user, then if the password provided belong to the current user of the system, the transaction is processed and a message display to notify the attendant that the transaction performed is still pending approval by an administrator.

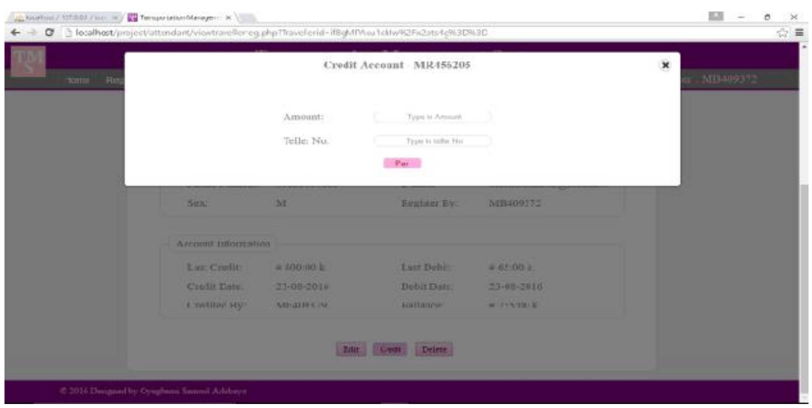

Figure 13: Credit Account Page

The administrator has the privilege of approving every major transaction, such as crediting passengers' account, registration of new system user and assigning them a role in the system either as an Attendant or an Administrator before it can be effective in the system. All the tellers for the day's payment are submitted to the admin offices, and the admin then carries out verification checks to ensure that each of the initiated payment transactions corresponds to the submitted tellers. If teller exists, then he approves the payment, otherwise, the payment is rejected. Figure 14 shows the page of pending payments.

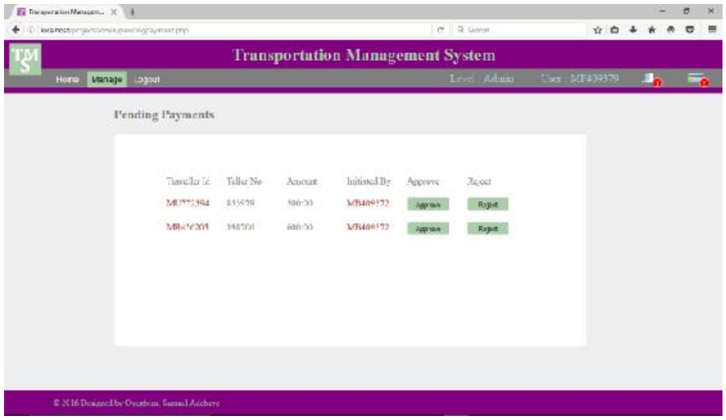

Figure 14: Pending Payment Page

After the payment is approved by the Administrator, the new balance can then be accessed from the passenger's detail page. Figure 15 shows the passenger's detail page containing passengers account balance.

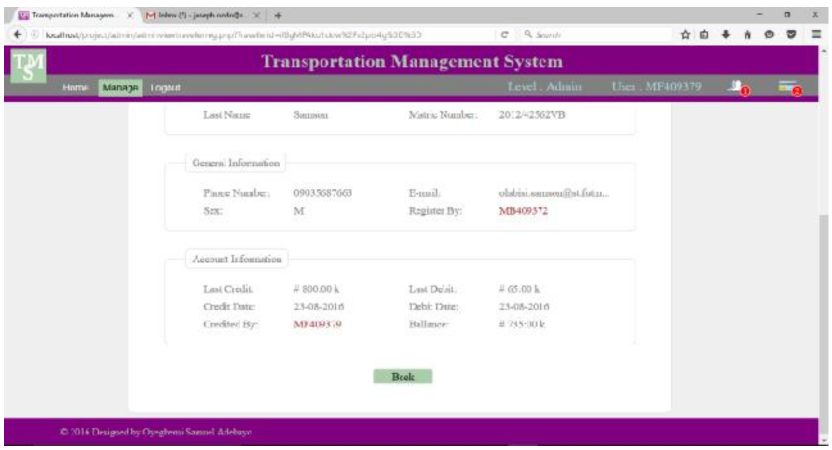

Figure 15: Passenger's Details Page

The attendant can also initiate travel. To initiate a travel, the location is first selected, then the system gets the available vehicle at that particular location selected, leaving out the ones that have been labeled faulty by the admin. Then the attendant can now select which of the retrieved vehicle is ready for travel. Figure 16 shows the page to select a vehicle for travel.

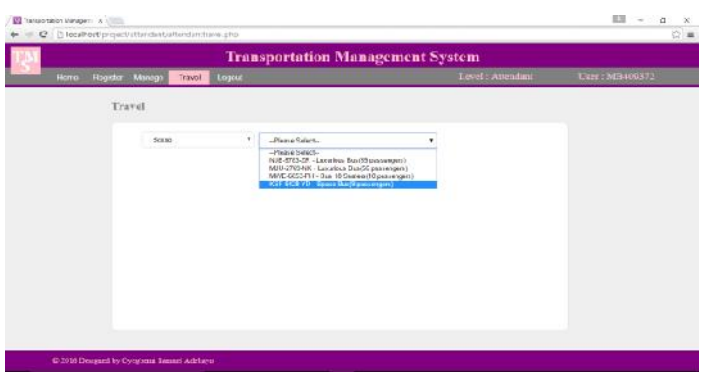

Figure 16: Vehicle Selection Page

The price, maximum number of passengers, and other information are retrieved from the system;

the bus is set to accept passengers. Each passenger then swipes their RFID tag on the reader to be added to the selected bus. If a passenger swipes a tag, and the information about the tag does not exist in the database, the system indicates the non-existence of the user by turning on the red LED to indicate that the tag is not yet registered. If the user exists but does not have enough balance, the amber coloured LED turn on to indicate an insufficient balance, otherwise, the system accepts passenger by turning on the blue LED and add the passenger to the selected bus. Figure 17 shows the designed wireless RFID reader.

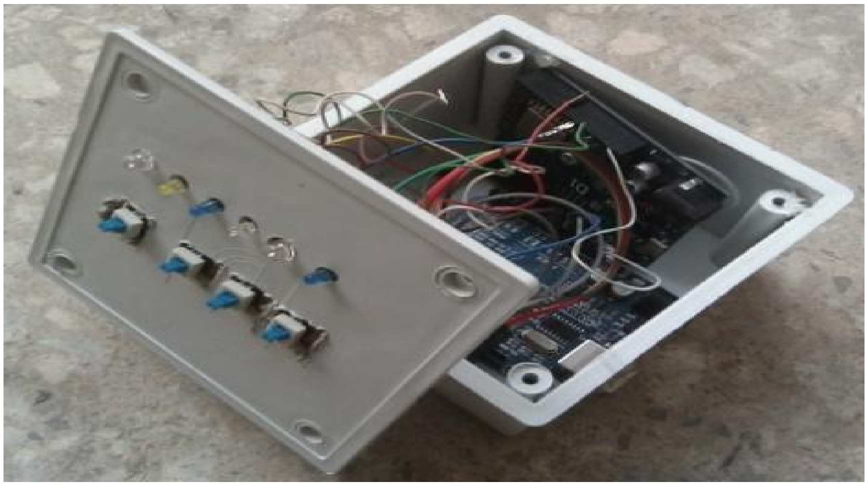

Figure 17: Developed Wireless RFID Reader

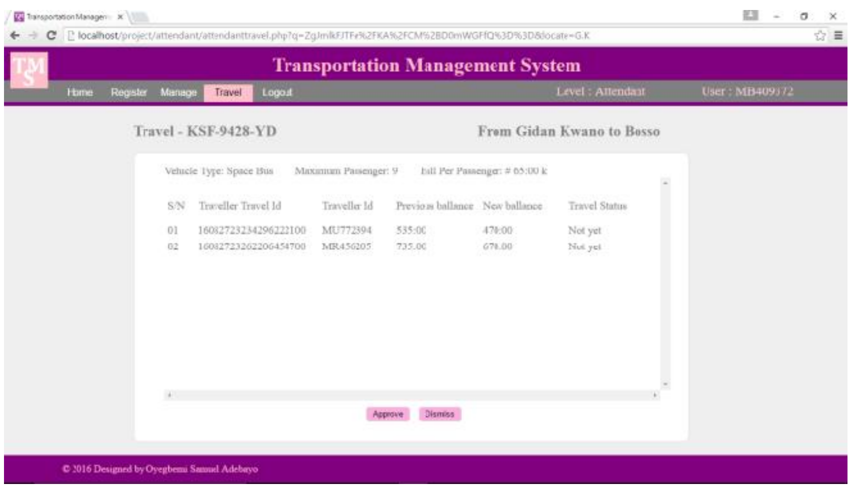

Figure 18: Attendant's Page for Travellers in Bus

Once there is at least one passenger in the bus, the attendant can decide to approve or dismiss the travel. If the attendant clicks the approve button, the system prompts the current user to supply a password, this is to ensure non-repudiation. Figure 19 shows the password alert for approvers to proceed.

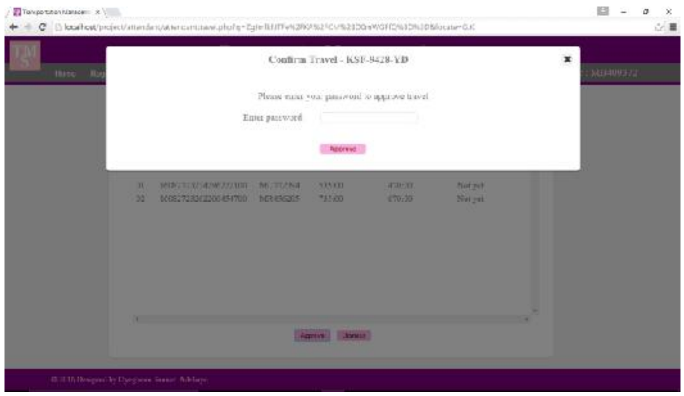

Figure 19: Password Prompt for Traveller Approval Page

When the attendant provides the correct password, the system deducts the fare from the individual passenger's account and their information would be saved in the database. This work uses qualitative metrics to evaluate the system performance. This metric includes the system accuracy in terms of true acceptance, false acceptance, true rejection and false rejection of the system users, and also based on the response time or latency of the system, which is the average time to respond to each passenger at the point of travel. The accuracy of the system is measured using the formula in equation 8:

$$AC = \frac{TA+TR}{TA+FA+TR+FR} \times 100 \ \ldots \qquad (8)$$

Where, AC = Accuracy, TA = True Acceptance, TR= True Rejection, FA =False Acceptance, FR=False Rejection.

The response time metrics quantify the duration for which a user must wait for the system to respond to a query, regardless of how quality and precise the response is. When combined with the accuracy of the response, minimum latency assures the best end-user experience when the system is under normal condition. In the case of this work, the response time involves the software response time to query which includes the request latency, i.e. the time required to get data from the database, the time required to load the HTML page into the client browser, and the time to get all the browser elements needed by the page which is being referenced by the HTML, such as images, the style sheet, and the JavaScript source for the page quality performance. Furthermore, the response time also involves the time required for the RFID reader to get a user tag ID, process it by sending it to the server through the Wi-Fi shield. All these delays make up the overall response time for this system.

The average response time of the system per unit user is expressed by the formula in equation 9.

$$ART = \frac{\sum_{i=1}^{N} RT_i}{N} \quad \ldots \qquad (9)$$

Where, ART = Average Response Time, N = Number of Users, RT= Response Time per user, i= test index. The system is tested with fifteen (15) different users (i.e. N = 15) at the point of travel, nine (9) registered, six (6) unregistered. Of the registered travelers in this test, seven (7) have been credited while two (2) has zero balance. The result of the test which includes the accuracy and the latency in responding to each of the travelers is shown in table 1.

Observing the result of the test as shown in table 1, passenger 1, 2, 5, 6, 7, 12 and 15 were registered and they all had sufficient balance in their account, thus the system accepted them. This was marked as true acceptance. Passengers 4, 8, 9, 10, 11 and 13 were not yet registered and the system rejected them, this was marked as true rejection. Passengers 3 and 14 were registered but have not been credited, thus the system indicated that they do not have sufficient balance, thus preventing them from having access to the vehicle, this was also considered a true rejection. While each passenger swipes their tag, the time taken from the database to respond to the query was recorded. The graph of the above result is shown in figure 20.

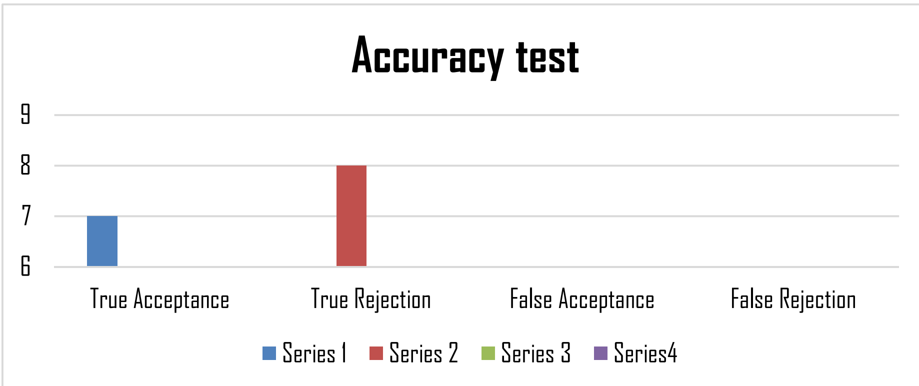

Figure 20: Accuracy Graph Result

From the result of the test, the average response time and the accuracy of the system can be calculated using equations 9 and 8 respectively.

Hence, TA= 7, TR =8, FA=0, FR=0.

Therefore, $AC = \frac{7+8}{7+8+0+0} \times 10 = \frac{15}{15} * 100 = 100\%$

Also for the average response time:

N = 15; $RT_1 = 0.3; RT_2 = 0.2; RT_3 = 0.3;\ RT_4 = 0.2;\ RT_5 = 0.4;\ RT_6 = 0.2;\ RT_7 = 0.2;\ RT_8 = 0.4;\ RT_9 = 0.4;\ RT_{10} = 0.3;\ RT_{11} = 0.2;\ RT_{12} = 0.4;\ RT_{13} = 0.2;\ RT_{14} = 0.3;\ RT_{15} = 0.3$

Table 1: Result of Accuracy Test

TSN	TA	TR	FA	FR	RT, sec.
1	✓				0.3
2	✓				0.2
3		✓			0.3
4		✓			0.2
5	✓				0.4
6	✓				0.2
7	✓				0.2
8		✓			0.4
9		✓			0.4
10		✓			0.3
11		✓			0.2

12	✓				0.4
13		✓			0.2
14		✓			0.3
15	✓				0.3

Therefore, from equation 9, Average Return Time (ART) is calculated as follows:

$$\mathrm{ART} = \frac{0.3+0.2+0.3+0.2+0.4+0.2+0.2+0.4+0.4+0.3+0.2+0.4+0.2+0.3+0.3}{15}$$

$$= \frac{4.3}{15} = 0.29\ \mathrm{secs}$$

From the calculated results, it can be seen that the accuracy of the system is 100% when tested on fifteen users, while it has an average response time of 0.29 seconds. This implies that the system does not falsely reject or accept any user. The average response time is as well moderate, even though the response time varies from one user to another. Reason for the difference in latency is as a result of the variation between the hardware trigger delay and the server response delay.

CONCLUSION AND FUTURE WORK

In this work, an inter-campus transportation billing system has been developed using a secure RFID authentication method. This system has addressed challenges in the Federal University of Technology, Minna transportation system by employing an automated billing system using students ID card embedded with RFID tags, thereby making payment ease and eliminating the need for additional expense in procuring an RFID tag for each user when the project is to be executed, hence, saving the University initial cost of project implementation. This work has also addressed the issue of vehicle management by automating the process. The response time per user of the university transportation system has also been improved from an average of 6 to 0.29 seconds. Furthermore, this project has also enhanced the transparency of the income generated by the University from the transportation system, since the payment is no longer a manual process.

In the future, this work could be improved by incorporating a hybrid or multiple authentication systems, such as fingerprint biometric with RFID authentication to avoid abuse and theft of student ID card which is the RFID tag used in this work.

REFERENCES

Bukohwo, E. M., & Ature, A. (2014). The Design and Implementation of Taxi and Bus Transportation Management System: A Case Study of University of Agriculture, Makurdi. *International Journal of Advanced Research in Computer Science & Technology, 2*(3), 10-13.

Chandra, P., Keshari, R. K., & Soni, P. (2014). RFID-based Ticketing for Public Transport System: Perspective Megacity. *International Journal of Advance Research in Computer Science and Management Studies*, 187-191.

Finkelzeller, K. (2008). *The RFID Handbook.* Munich: John Wiley and Sons, Ltd., Publication.

Kalal, G., Bisht, R., Tikar, M., Yatnalkar, G., & Chaware, S. (2014). "Tap & Pay" Universal Transport Billing System Using RFID Smart Card. *International Journal Of Engineering And Computer Science*, 9260-9264.

Kerschbaum, F., Lim, H. W., & Gudymenko, I. (n.d.). Privacy-Preserving Billing for e-Ticketing Systems in Public Transportation. 1-19.

Kumaki, T., Fujita, T., Nakanishi, M., & Ogura, T. (2013). Morphological Pattern Spectrum and Block cipher processing based image-manipulation detection. *Nonlinear Theory and Its Applications, IEICE, 4*(4), 400-418. Retrieved 09 03, 2016

Mithlesh, C. (2013). An Automated Transport Management System. *IOSR Journal of Computer Engineering (IOSR-JCE), 11*(3), 17-21.

Mor, P., Sharma, H., & Sodhi, A. (2014). Smart Transport Management System Implemented Using Two-Way Encryption Mechanism in RFID. *International Journal of Future Computer and Communication, 3*(4), 242-246.

Palmer, S. R., & Felsing, J. M. (2002). *A Practical Guide to Feature Driven Development.* Upper Saddle River: Prentice Hall.

Peng, K., & Bao, F. (2010). A Secure RFID Ticket System for Public Transport. *Springer, Data and Applications Security and Privacy*, 350-357.

Peris-Lopez, P., Hernandez-Castro, J. C., Tapiador, J. M., & Ribagorda, A. (n.d.). LMAP: A Real Lightweight Mutual Authentication Protocol for LOw-cost RFID tags. 1-12.

Robomart. (2015). *RC522 RFID Reader/Write For Arduino*. Retrieved 7 8, 2016, from Robomart Website: https://www.robomart.com/rfid-modules/buy-rc522-rfid-reader-writer-arduino-compatible-online-india

Solanke, M. (2013). Challenges of urban transportation in Nigeria. *International Journal of Development and Sustainability Online ISSN: 2168-8662* , 892.

