A Microcontroller Based Electronic Payment System for Cashless Transportation Systems

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Abstract- ***In Nigeria, the transportation system still uses the cash system for payment. This wastes a lot of time and also there is the problem of obtaining balances. There is therefore the need to develop a smart system that can be used for payment. This paper presents a report of a project that aims at using microcontrollers and Radio Frequency identifies (RFID readers and cards) to tackle the problems of current public transportation payment system. Our application will make use of RFID cards in online payment using 'e-money' system. 'e-money' is money in electronic form, that takes the form of a card which has money balance stored on it through electronic means. Once this money is recorded or loaded on a card it ceases to have association with any account but exists just as a claim on some financial institution. When a passenger boards a vehicle, his tag is scanned using the RFID reader and the transport cost is automatically deducted from the card. A prototype of the system developed and tested in the computer laboratory of Federal University of Technology Akure (FUTA) is found to be very effective and efficient as a transportation payment method.***

Indexed Terms- ***Cryptocurrency, RFID, Microcontroller, e-money, Cloud***

I. INTRODUCTION

Public transportation services in Nigeria are still being paid for using cash. There are a lot of problems associated with this primitive method. The world today is going digital. The use of electronic smart card for transport services is now becoming a viable option for many organizations, countries, campuses and so on. Recently transport operators and other service providers have begun the introduction of smart cards systems to either complement or replace existing means of payment. The way in which fares, tolls and other fees are collected is one of the most important aspects in determining customers' satisfaction.

The evolution of cashless transactions according to Seth (2017) is as follows:

The first publicized cashless transactions was made by cryptologist and inventor, David Lee Chaum. He introduced the idea of digital cash in a research paper in the year 1983. He later established DigiCash Inc. in 1990, a corporation in Amsterdam that dealt with electronic money and doing away with the need for bank intermediation (Seth, 2017).The company became insolvent and got sold to eCash in 1998. Then, in 1997 mobile payments started. Coca Cola introduced some vending machines which customers could buy from by setting up a transaction system with the machine via SMS instead of dealing in coins and change (Seth, 2017).

In the same year, Merita Bank, based in Finland and now merged with the Swedish Nordbanken, started the trend of mobile banking. PayPal, started in 1998, which gave the world a large online system to make payments as against cheques, drafts, money orders and other conventional methods. Another system, 'E-gold', founded in 1996 by Gold & Silver Reserve Inc. allowing users to open accounts holding grams of gold as opposed to digital money. However, due to rising fraudulent activities, it was raided by US Feds in 2005 (Seth, 2017).

In 2008, bit coin was introduced, which marked the start of digital currencies, and was made decentralized in 2009. It is a form of secure, crypto-currency which has revolutionized the world of alternative payment modes.

II. LITERATURE REVIEW

2.1 Smart Cards

According to Blythe (2004), a smart card is essentially a credit-card-sized piece of plastic which has a microchip embedded in it. This chip is the smartness' of the smart card, and performs all the functions required by the card (storing data, processing data, writing data, etc.). Smart-card chips come in two broad varieties: memory-only chips, with storage space for data, and with a reasonable level of built-in security; and microprocessor chips which, in addition to memory, employ a processor controlled by a card operating system (similar to any PC), with the ability to process data onboard, as well as carrying small programs capable of local execution. The main storage area in such cards is normally EEPROM (electrically erasable programmable read-only memory), which subject to defined security constraints can have its content updated, and which retains current contents when external power is removed (analogous to a PC's hard drive). Newer smart-card chips may have dedicated co-processors to perform certain functions at optimum speed (such as complex cryptographic routines required for certain security regimes) (Blythe 2004).

2.2 Related works

Mor Sharma and Sodhi (2014) present a secured smart transport management system using radio frequency identification and transport management application. RFID tag are used for automatic fee deduction at car parks. Every vehicle is equipped with a RFID tag and has an associated account. When vehicles checks in and checks out, the time spent in the stand is calculated. The amount will be deducted from this account only. Customers have to refill their account at the beginning of the month. It is a secure and efficient way for fee collection. Similarly, system deducts the toll tax. There is no need to stop the vehicle at barrier. Reader will scan the tag and search for the associated account. If there is enough amounts in the account then vehicle can move uninterrupted through the toll otherwise it will not be allowed through the barrier located ahead of the toll collection center.

Bisht (2015) presents a universal transport billing system using RF-ID (Radio Frequency Identification) that integrates all billing applications into one system. In public transportation system at present we use paper tickets which are printed by a small machine with a key pad. The RFID card is used for billing of transport systems including bus payment, toll payment, petrol payment, and parking module. The amount is deducted from passenger's account according to the mode selected by passenger. The main advantage of the system is that the transaction and fare calculation is automated and secured.

Jadhav et. al. (2017) presents automatic toll payment system. It allows users to pay the prepaid toll using the RF card. The money is automatically deducted from the users bank account as soon as the vehicle approaches the TOLL and user also get an acknowledgement SMS. If that vehicle is stolen vehicle, then SMS will be sent to the police.

Yadav, Yadav, Sawant and Katkar (2017) presents "Cashless Campus: Fund Management Using Micropayment Technique". The objective is to have a single multifunction campus card offering cashless, catering, transport and other services. The technology adopted is Barcode (QR technology). That means students do not need to keep cash to purchase anything inside the campus, they just need to scan the card given to them. The transactions made by the users are updated in the databases and monthly statements about the transactions are provided.

Nair, Pawar, Tidke, Pagar and Wani (2018) present Online Bus Tracking and Ticketing System. The authors recognize that transportation system still uses the traditional ways for ticketing. Therefore there is the need for a smart system which provides real time information of bus and gives an easy way to purchase a ticket. They proposed android application which overcomes the disadvantages of the current public transportation system. The application will track the bus, punch bus-passes having QR code, also supports on-time ticketing using E-wallet or cash and generates ticket with the help of Blue-tooth printing. This wastes money on the bus passes.

Karthika et al. (2018) proposes an automated card driven system using RFID and GPS for bus journeys

in India. While the GPS will be used to track the vehicle for distance covered, the RFID will be used to identify a passenger and for payment purposes. The objective is to reduce the cost of printing paper tickets. Although the security of the work was not considered, the work formed our motivation.

III. THE PROPOSED REMOTE SYSTEM

The proposed system consists of the hardware subsystem and the software subsystem. The hardware subsystem consists of microcontroller board, local server, and hardware interface modules. Local server controls hardware interface module, and can be easily configured to handle more hardware interface module. Dragino Wi-Fi module technology is used as the network infrastructure that connects server and hardware interface modules. This is chosen to improve system security (by using secure Wi-Fi connection), and to increase system mobility and scalability.

3.1 System Architecture

An overview of the proposed system architecture is shown in Figure 1. The system consists of a web interface developed using HTML, Bootstrap, PHP CSS and Ajax, and a Seeeduino Cloud microcontroller board. The Seeeduino Cloud microcontroller is the main controller that performs the necessary actions that need to be

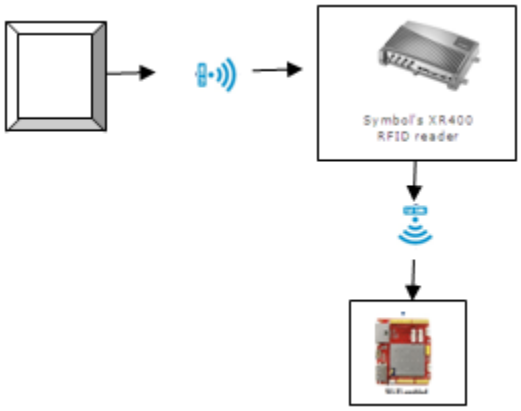

Figure 1 the System Architecture

a. Microcontroller layer: This consists of Seeeduino Cloud micro controller board with inbuilt ATmega32u4 and Atheros AR9331 processors. Seeeduino Cloud is a microcontroller board based on Dragino Wi-Fi IoT module HE and ATmega32u4. HE is a high performance, low cost, 2.4G Wi-Fi module which with an Open Source OpenWrt system inside. It consists of ATmega32u4 which facilitates programming and incorporation into other circuits.
b. RFID Reader: The Reader reads the data from the tag and it to a computer or network which houses interface software known as Middleware. Information is now available to users. Depending on the RFID system, the information could include: item's current location,
c. RFID Tags. These are small electronic components having Antenna and Silicon chip. The Tag is also called a Transponder. It responds to a signal from the Interrogator (reader). The Tag comes in a variety of shapes. It is made up from a chip (IC) and an antenna. Depending on your application it may be embedded in glass, or epoxy, or it may be in a label, or a card.
d. Jumper wire – For connecting components together.
e. Modem – A modem (modulator-demodulator) is a network hardware device that modulates one or more carrier wave signals to encode digital information for transmission and demodulates signals to decode the transmitted information. Thus, used in this project for providing internet connection.

3.2 System Prototype Design

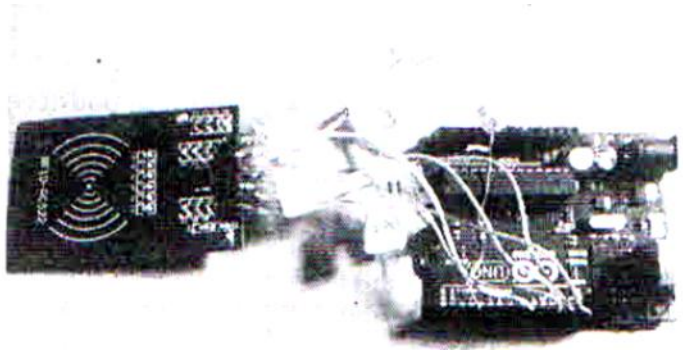

Figure 2. The system Prototype Design

The prototype of the proposed system has been developed in Computer Science department of Federal University of Technology (FUTA) as shown in Figure 2. A tag is passed across a reader wirelessly. The reader is connected to a Seeeduino Cloud microcontroller board through a wireless

media. Wi-Fi enabled board is the nucleus of the system where all other components are connected. The microcontroller board is to be supplied with 5V, the appliance taps it power energy from the 220v power outlet.

3.3 The System Software

The software subsystem presents an interface for the use to remotely control the appliances.

The overview development tools that will be used to develop the user interface of the proposed system will be on the focus in this section.

- ARDUINO IDE: The Arduino software, built using embedded C language, using IDE comes with the microcontroller itself. Arduino software is responsible for collecting events from connected sensors, then applies action to actuators and pre-programed in the server.

IV. THE SYSTEM IMPLEMENTATION

The system requirements and implantation logic is presented in this section implemented

4.1 SYSTEM REQUIREMENTS

The specification of system requirements is essential for effective implementation of the developed system. This project can be better described by dividing into two categories, namely:

i. Hardware
ii. Software

4.1.2 HARDWARE

The hardware requirements to develop the system include:

i. Computer system with Processor type- Intel Dual core or higher.
ii. Minimum RAM of 2GB.
iii. Microcontroller board
iv. USB cable
v. RFID Reader
vi. RFID Tag
vii. LED
viii. Internet must be available for connecting remotely.

4.1.3 SOFTWARE

i. Microsoft Windows vista/ 7/ 8 or Linux OS
ii. Arduino IDE
iii. XAMPP Apache server

Once the system is powered up, and a funded card is placed close to the Reader, the reader reads the tag and the transport cost is deducted from the card. This will put on the LED light as shown in Figure 3.

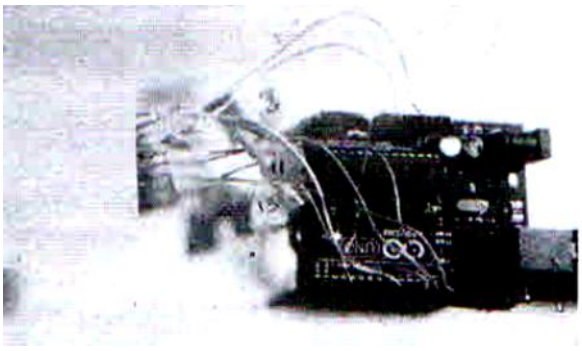

Figure 3 Card with fund

When there is no more cash in the card and is placed close ti the reader, The LED light will not be put on as shown in Figure 4.

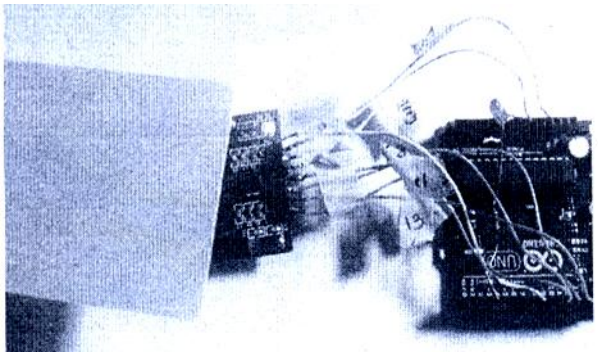

Figure 3 Card without fund

V. CONCLUSION

This work proposes a low cost, electronic payment system for cashless transportation. The approach discussed in the paper is novel and has achieved the target to accept payment for transportation. The system design and architecture were discussed, and prototype presents the basic level of transport payment has been implemented. Finally, the proposed system provides a convenient way of

paying for transport service. The following are the benefits of the proposed system.

i. No need of cash. The system does not require the clients to carry cash about for transport purposes.

ii. No need for given change: There is no need for looking for change and hence no more wasting of time.

iii. System Usability: Scalability is the ability of a system, network, or process, to handle growing amount of work in a capable manner or its ability to be enlarged to accommodate that growth. For example, system upgrade/downgrade by adding/removing hardware interface module should be easy and systematic task.

VI. RECOMMENDATIONS

In view of various problems associated with cash payment for transport, it is recommended that the system should be fully implemented for convenient payment of transport cots.

VII. LIMITATIONS

i. This system only supported e-money method only. Automatic deduction from bank account is not supported now.

ii. Wide Area Network (WAN) and Mobile technologies are highly needed for the system to function.

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