

# Implementation of a Radio Frequency Identification (RFID) based Cashless Vending Machine

Benson-Emenike, M. E.  
Federal University of Technology,  
Owerri, Nigeria

James, G. G.  
Rhema University, Aba, Nigeria

Chwukwu, E. G.  
Federal University of Technology,  
Ikot Abasi, Nigeria

Michael, N. A.  
Ritman University, Ikot Ekpene, Nigeria

**Abstract:-** This paper reports the Implementation of a Radio Frequency Identification (RFID)-based multiproduct vending machine. It is designed to automatically dispense drinks such as coke, malt and yoghurt using RFID prepaid method system. After a careful analysis of the existing system, noting its shortcomings, a new system was designed and developed such that the shortcomings of the old system were carefully overcome. The system was designed using Microcontroller (Ardiuno Mega board), RFID tag/card reader, servo, Liquid Crystal Display (LCD) and other electronic devices. Prototyping methodology was adopted and the machine parts (hardware and software) were designed in modules. These modules were then separately tested and found to be functioning as desired. They were then integrated to form the finished product. A C-language based software that is able to drive a multiproduct vending machine was designed and implemented in this work and it made the hardware components to function in a well-co-ordinated manner. The customer can buy product using RFID card by swiping the card across the RFID card reader, then the embedded system reduces the amount from the card, shows balance on the LCD display and the product which is stacked in the machine plunges out of each funnel inside the machine (this is controlled by a servo attached to the microcontroller) and accessed via the dispensing unit outlet. The vending machine developed in this thesis uses a PC as a guide to connect to the machine especially for generating recharge codes. The RFID based multiproduct vending machine was compared with the cash-based alternative and found to outperform it in terms of flexibility, efficiency and security and has a better way of managing the financial return to the business due to the prepaid method of recharging the RFID card.

**Keywords:-** LCD, Microcontroller, multiproduct vending machine, etc.

## I. INTRODUCTION

Automated Vending machine (AVM), a coin operated engine that is used for retails (Holcombe, 2017). It is a robotic device which provide products like snacks, beverages, cigarettes and lottery tickets to consumers on payments made through the insertion of cash, a credit card, or specially designed card into the AVM. The pioneer among AVM was the type that was developed in England in the early 1880s, as well as the dispensable postcards. The

AVM has been in existence in most part of the world, especially in the first world; in recent times, a more automated of these types of machine were developed to provide less common items to consumers, compared to the traditional versions (Sharma, 2014).

A vending machine has two functions namely, selling of product and service to the customers. A vending machine sells the products that are installed into the body, each with its own different price. The device released and make available the items requested for at the bottom part of the AVM, after payments verification (Holcombe, 2017). For the vending machine that provides service as its main function, the service also may become available after payment is inserted. Example of services vending machine is Money ATM vending machine.

There are three techniques of payment used with vending machines. Many vending machines are capable of giving change, and some of the more modern ones accept paper money or credit cards. Vending machines may be classified according to technique of payment as follows:

- Coin operated vending machines.
- Note operated vending machines.
- Prepaid operated vending machines.

There are three major problems with the payment method nowadays. That is tank full with coins, the notes cannot be read and also the notes or coins always stuck in the machine.

More coins are not accepted into the AVM coin box after the tank have been filled with coin, as such purchases cannot be made. Some AVM are spiral in nature, as they make use of these spiral mechanisms to separate and to hold the items. At the cause of vending, the spiral mechanism will spin, the product are been push forward to fall out to be vended. If the products and the spiral are misaligned, the spiral may turn but not fully release the product (Kerry, 2002). The product will stick in the middle of the vending machine. The vending machine automatically will stop operation when this condition occurs.

Secondly, the inability to read the notes and coins is a major problem related to the payment method. However, the notes must be in a very good condition for AVM that used notes as the method of payments. Good condition here means such notes must not be folded, it must be a clean notes and must not be counterfeit. The AVM will rejects payments as a results of inability to read crumpled and dirty

notes that are in bad condition. Similarly, most AVM may reject quarters and other coins.

Whenever there is a wrong insertion of coins or notes into the wrong direction, the machine will stop accepting payments and as a result stop vending; with this, the only solution is to employ the services of the manufacturers to maintain or repair the machine. Similarly, The machine may have the problem of pattern recognition as a result of inserting coin that are foreign currencies which may have the same size and shape as the acceptable coin with the intention to acquire a cheaper merchandise; this may cause the machine not to accept such payments. Making use of these foreign currencies may cause the AVM to develop critical issues and as a result the payment may be stocked up (Kerry, 2002).

The "Identification Friend or Foe" (IFF) [Wiki-RFID] [Wizard War] used by the British during the Second World War was the first RFID application. In these RFID applications, transponders were placed into fighter planes and tanks, and reading units could query them to decide whether to attack. The armies around the world today are still using the successors of this technology.

After the IF RFID application was the "Electronic Article Surveillance" (EAS) which became the first commercialised RFID application which was created in seventies to act as a theft preventing system (TPS). The EAS were based on tags which could store single bit that was read whenever customers left the store and did not unset the bit, the system alarm would sound.

The RFID tags came to lime-light during the late seventies when it was used in the agricultural sectors to carry out animal tagging. When the Norway and many States in the United States of America (USA) decided to implement the RFID in the toll collection on their roads [EZ-Pass] in the early eighties, the RFID technology received a boost. Large numbers of solutions like ski passes, Speed Pass and money cards were brought in through decades as additional to collections of toll. The Auto-ID Centre was founded at MIT in the 1999 which was saddle with the task of development of global standard for item-level tagging. In the year 2003, the after completing the work on the Electronic Product Code (EPC), the Auto-ID was closed and at the same time, the EPC global Inc. that was newly founded continues the work. The paper tagged "Communication by Means of Reflected Power" that was published by Harry Stock man in October 1948 was the first RFID paper. These project was patent in 1973 for a passive radio transponder with memory [US. Patent 3,713,148] (C Jechlitschek, 2006). This paper proposes the design of an intelligent RFID based cashless vending machine for sales of drinks. The proposed system is made up of a multi-select drinks machine with RFID based payment system. The user will swipe RFID payment Card on the machine and then select the drink he/she wants to buy. The card system includes the RFID which consist of RFID reader and RFID tags. Using these tags drinks can be vended without human interaction or involvement of fiscal cash. A prototyping methodology was used to achieve the software design aspect

the propose system which considers previous paying bills method for vending machine, and makes payment by using coins or notes. C-language based software that is able to drive a multiproduct Vending Machine was developed in the course of this paper; An RFID payment system was also incorporated to make the Vending Machine cashless in operation. When this RFID-based Vending Machine is compared with the cash-based alternative, it is noted that the RFID-based has out-performed the cash based in terms of efficiency, security and sales tracking and it is therefore a better machine used for sale of drinks.

## II. LITERATURE REVIEW

As trade and transport markets grows, it makes physical object identification has become increasingly more important. Barcode which was the first automatics identifier for product, have their flaws such as the need to align the barcode with the scanner and being able to only scan one product at a time. And better auto-ID systems have therefore been developed. A well-known of this technology which lacks the aforementioned flaws is the RFID. This technology make use of radio waves to track the RFID tag attached to the physical object which is envisioned as a replacement for its barcode counterpart.

The RFID tag is a small microchip designed for wireless data transmission that is generally attached to the antenna in a package that resembles an ordinary adhesive sticker. The microchip itself is about 0.4mm<sup>2</sup>, which is as small as a grain of sand (Juels, 2005) and it is responsible for the transmission of data via the air in response to interrogation by an RFID reader. RFID Advocacies understand RFID tag as a successor to the optical barcode familiarly printed on consumer products with two distinct advantages:

- **Unique Identification:** A barcode shows the category of items that is printed e.g. "That 100g bar of ABC brand and chocolate of 70%", this makes the RFID tag to go additional one step. It emits a unique serial number that distinguishes among many millions of identically manufactured objects; it might indicate e.g. that "This is 100g bar of ABC brand, 70% chocolate, serial No: 897348738".
- **Automation:** Barcodes as an optical scanner, can be carefully scanned as a well-positioned object but will require line-of-sight contact with readers. This means it required to be operated by human. In a summary, aside line-of-sight contact and accurate position, these tags can be readable. RFID reader are capable of scanning tags at rates of hundred per second. According to Juels, (2005), RFID reader by a warehouse dock door for instance are capable of scanning a stacks of passing crates with precision (Juels, 2005).

RFID is the wireless applications of electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects which contains information that are electronically stored. Most RFID acted as passive transponder by collecting energy from the interrogating radio waves, while others operates at hundreds of meters from the readers through the special

inbuilt or active power source such as a battery. However, the barcode may be embedded into the tracked objects which does not necessarily need to be in line of sight of the reader. This makes RFID one of the methods that enhances

effective and automated identification as well as data capturing. Figure 1 shows sample of RFID tag and its reader:

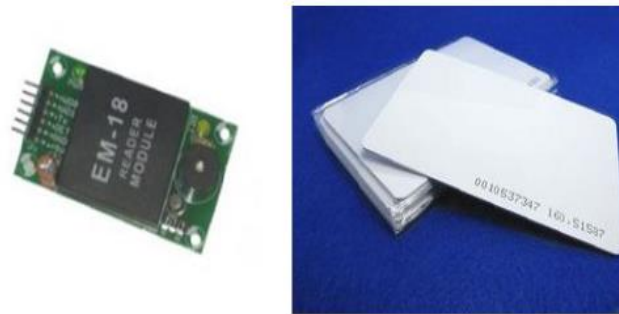


Fig. 1: RFID tag and reader (Juels, 2005).

An RFID system applies tags or labels to the objects to be identified. Through two ways by sending signals to the tag and reading its response through the interrogators. This system can be either passive, active or battery assisted where the active tag has an on board battery which periodically helps to transmit its identification signal. These tags which may either be read only with a factory assigned serial number that is used as a reference key which are keyed into the database or may be read or write contains two parts which are made up of; integrated circuit (ICs) for storing and processing information, modulating and demodulating a radiofrequency signal and antenna for receiving and transmitting the signal tag information stored in non-volatile memory, this helps the RFID reader to transmits an encoded radio signal to interrogate the tag (Juels, 2005).

The RFID tags receive the message and respond with its identification and other information. This may be unique tag serial number or other specific information.

### III. HOW THE RADIO FREQUENCY IDENTITY WORKS

The report on “RFID SECURITY” presented in 2008 by the Government of the Hong Kong Special Administrative Region, narrate that RFID technology is a non-contact, automatic identification technology which make use of radio signals to identify, track, sort and detect a variety of objects including people, vehicles, goods and assets without the need for direct contact found in magnetic stripe technology or line of sight contact found in bar code technology. RFID technology has the ability to also track movements of objects through a network of radio-enabled scanning devices over a distance of several meters”.

They said a “device called an RFID tag (or simply a tag) is a key component of the technology. An RFID tag usually has at least two components:

- ICs to modulate and demodulate radio signals and performed several functions;
- An antenna for receiving and transmitting the signal.

RFID tag can perform a limited amount of processing and has small amount of storage and these tags are sometimes considered to be enhanced “electronic barcodes”.

The RFID tags that lacks the presence of ICs are referred to as RF fibres. These tags use “fibres or materials that reflect a portion of the reader’s signal back and the unique return signal can be used as an identifier”. Systems that make use of RFID technology are typically composed of three key elements:

- An RFID tag, or transponder, that carries object-identifying data.
- An RFID tag reader, or transceiver, that reads and writes tag data.
- A back-end database, that stores records associated with tag contents.

Each tag contains a unique identity code which enables the RFID readers to emit a low-level radio frequency magnetic field that energizes the tag and also responds to the reader’s query and announces its presence via radio waves, transmitting its unique identification data. Such data are decoded by the readers and passed to the local application system via middleware.

In between the reader and the application system of the RFID, the middleware acts as the interface. In the host database or backend system, the stored information as well as the identities are track and matched by this system, as such authorization of subsequent processing could either be granted or rejected base on the output received by the reader (Jaffe, 2006).

### IV. SYSTEM ANALYSIS

#### A. Analysis of the existing System

Here, description of VM including intelligent approach and challenges are considered. Basically, VM provides several different types of items when money is inserted into it. The VMs are more practical, easy to use and accessible for user than the standard purchasing method. They can be found everywhere for different kinds of products such as snacks and cold drink, coffee, tickets and diamonds and platinum jewellers. The efficient implementation of these machines can be in different ways by using microcontroller and FPGA board. Figure 2 shows an abstract example of VM.

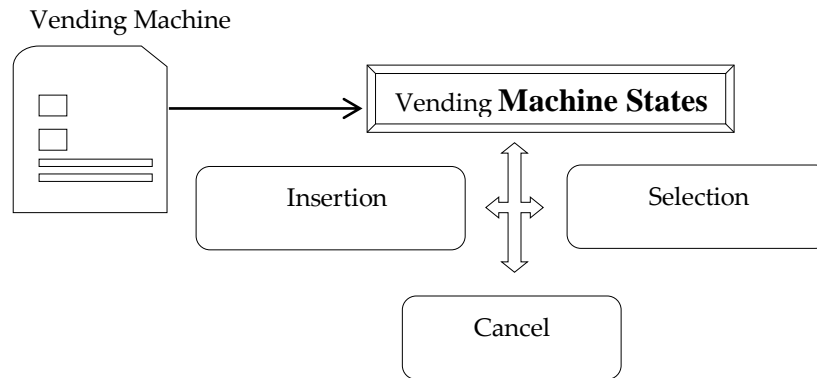


Fig. 2: Basic Operations of VM

### B. Basic Operation of VM

- The user inserts money, money counter sends to the control unit the amount of money inserted in the VM by the user.
- The operation buttons are active to choose the products that people like. According to the VM's internal program, VM dispenses the products when people insert the correct amount.
- If the program is designed to return the change, VM will return the change.
- When selected product is not available, VM will reject the service.

At the inception, the machine is instigated by pressing the reset button after the power supply is switched on. Then the coin must be inserted in its slot before selecting the required item. Immediately after these process, the coin sensor confirms whether the coin is valid or not. Based on the training given to the box, if the coin is valid, it will be accepted else, it will be rejected.

Checking of the availability of the product will also be initiated by machine, this is to enable the system verify if the required product requested for is available or not; and if it is available, the product will be delivered on request at the product state via the product output. If the required products are not found, then the control unit of the system will placed demand for servicing after which the machine will be automatically reset and as well the requested product will be delivered.

### C. Limitations/weaknesses of the Existing System

- The existing vending machine payment system suffers from the following challenges.
- Since vending machines are usually displayed in public areas they can suffer vandalism especially due to the money tank/holder installed in the body.
  - Logistics can also be challenging, as a coin vending machine requires someone to empty the machine each day as the coin holder can fill rather quickly.
  - Some older coins are not easily readable by the mechanisms.
  - If product is out of stock, then also the vending machine will accept the money and the client will not get their money back.

- If a fake coin of same thickness, metal, and weight is made then, the coin detector might accept it, but it won't have 100% efficiency.

### D. The Proposed System

The design of vending machine has two approaches; the hardware component design and the software design. This paper was implemented using various components that are organized in a specific way so that the device is small and portable. Each component has a specific function to perform. The project is basically divided into three parts: mechanical, electronics and display unit. The vending machine is designed and operated by using RFID in place of using coin. The internal circuit consists of servo motor, LCD display, keypad, servo drive motor, Arduino Mega microcontroller, Potentiometer, RFID card reader, 2way switch, Push button, buzzer and IR sensor.

### E. Advantages of the Proposed System

- The proposed system has the following advantages.
- Once the transaction follows the correct programmed pattern of the machine, the entire process is automated and user friendly.
  - 24 hours services is made possible as free choice of purchasing at any time of the day are given to the clients.
  - The system is capable of taking care of products diversities.
  - There is possibility of the clients getting what they required at their convenient because these machine are station at strategic locations.
  - It is card payment based and therefore the issue of loss of money by the vendor is eliminated
  - There is reduction of overhead costs since it involves a one-time investment and does not required hiring of personnel.

### F. Research Methodology

Research methodology is define as the study of how scientific research are been carried out. It involves finding out the categories of data that are maintained, the searched facts to be search, ways of tracking these facts as well as ways to document the facts for future references. It involves diagramming notation of results documentation, procedural approaches, and quantification of ideas. The following are the available software development methodologies:



- OOADM- Object-Oriented Analysis and Design Methodology
- SSADM- Structured Systems Analysis and Design Methodology
- Waterfall Methodology
- Prototyping Methodology

This paper applied the prototyping method. This involves the instance of something acting as a standard for other things of the same category. In prototyping, before the beginning of production in this wise, a basis is built to test the function and status of the desired product. It is helps to immediately put together a workable model to enable the developers test several aspects of design, illustrate features-based ideas and put together early user’s feedback. Prototyping is mostly handled as a vital component of the design process of the system where developers believe is that it helps to reduce the risk and cock involves in the entire project. Promptly visible appearance of the prototype provides the user with the idea of what the system will looks like at last.

The prototype used in this paper considered the former vending machine bills payment method through the use of coin and notes. At this point, payments of bills by rechargeable prepaid card as well as creating links between the main systems with the subsystems so as to control and spot out the data like availability of products in the various subsystems are put in place. Every users are given an RFID tag card, such that when they make use of these card, they are able to access and purchase the available products of their choice at the centres.

Before making use of the card, it must firstly be recharge d since it is a prepaid. The card must be swept on the device reader module to initiate vending of product. This reader module used serial interfacing to interface with the microcontroller.

The microcontroller reads the information from the reader or module and asks the user to select the product required, which will be shown on the LCD of the screen. Then user is required to select the required product number through potentiometer which acts as an input to the microcontroller. After reading the value the microcontroller will check for the required balance in the smart card, if it is sufficiently available then the product selected will be dropped on the can. If there is no cash in the card, the system will communication the user by displaying “insufficient balance” on the LCD.

G. Data Collection Methods

The researcher relied on the following for the purpose of data collection:

- **Interview Method:** The researchers conducted a kind of amorphousdiscussion with a few individual within the sample frame to discover their view towards the subject matter of the research. The operational method of cash based vending machine was obtained.
- **Libraries:** The use of public and private libraries was intensively and extensively. Data were also collected from secondary sources such as books, periodicals, Journals, magazines and dailies. These data weremainly applied in this study to provide the theoretical framework. In other to broaden the research coverage, several materials from the internet were equally downloaded.

H. Specifications

Specifications of RFID Vending Machine (RFID-VM)

Table 1: RFID-VM Technical Specifications

Type	Specificaions
Model	Mifare MFRC522
Type	Passive
Battery	Batteryless
Host Interfaces	SPI (serial peripheral interface)
Success/Accurate rate	Low power, high frequency
Strength from tag to reader	Very low
Frequency spectrum	HF (High frequency spectrum)/Passive
Frequency ranges in Hertz	13.56MHz (HF, Passive)
Bytes in UID (unique identification number)	4bytes
Range in meters	< 1m (3 feet)

## V. SYSTEM IMPLEMENTATIONS

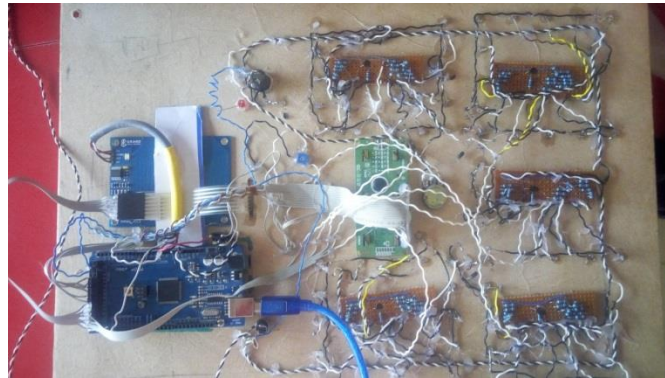


Fig. 3: Development Board Implementation: 89V51RD2 Flasher Board–Interface–RS232

This board is a 40 pin 8051 that is commonly design embedding a power supply circuit, an RS232 port for the purpose of serial interfacing with computer and other serial devices, reset switch, power status LED and a general-purpose switch and LED. It is suitable with the AT89S51/52 and the P89V51RD2 microcontrollers. The P89V51RD2 microcontrollers therefore permits serial programming that can be directly programmed with the board via a serial connection to a PC without the need of any other external programmer.

### ➤ Features

- It has an embedded MAX232 interface circuit which allows for easy communication with a computer and other serial devices.

- A power input DC plug-in jack.
- Ability of the board to accept AC as well as Dc input voltages via the embedded bridge rectifier.
- Availability of a filter capacitors and heat sink possessed by the embedded 5V regulator(LM7805).
- Possession of a green like power Status LED with a general purpose user LED(Red)
- Onboard quartz crystal 11.0592 MHz oscillator circuit
- A port extensions used by all ports
- External pull-up resistors for Port 0
- Vin, 5V and Gnd bus provided



Fig. 4: Product Input Box

The box has three input holes for maltina, coke and CD. The user can select the product he/she wants through the input key pad.

A. Input Design



Fig. 5: Input Design

The input pad allows customer to select the product/option of his interest (1, 2, 3, 4or 5) and then press BUY button. The Options run through

- Maltina
- Coke
- CD
- Recharge
- Check BAL

B. Vending Machine Design

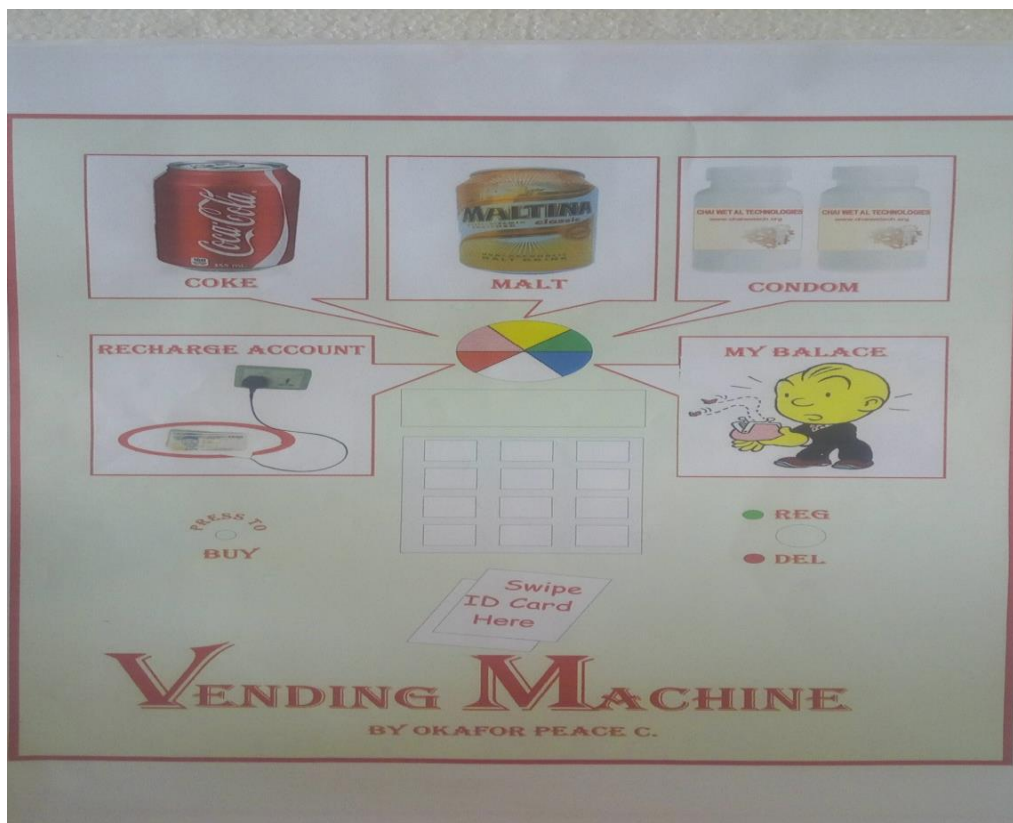


Fig. 6: Vending Machine Design

The machine is designed to have provisions for the following:

- Product Selection Box
- Account Recharge
- Check Balance
- Card Swipe
- Delete button
- Reg button

Each of the buttons executes a particular function assigned to it as shown in Figure 31.

The vending machine is loaded with drinks for customers to buy. For the design of the vending machine operations, it is required that the customer will have a card for making payment for the purchases.



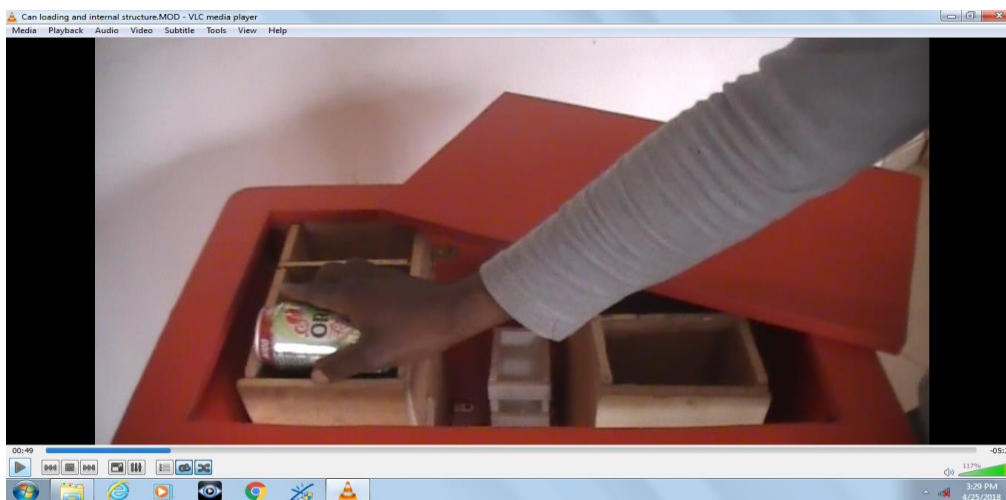


Fig. 7: The vending machine loading slot

It is specified that the customer should swipe the card on the machine to validate the payment card and check if it has enough balance to proceed with the purchase as shown in figure 8.

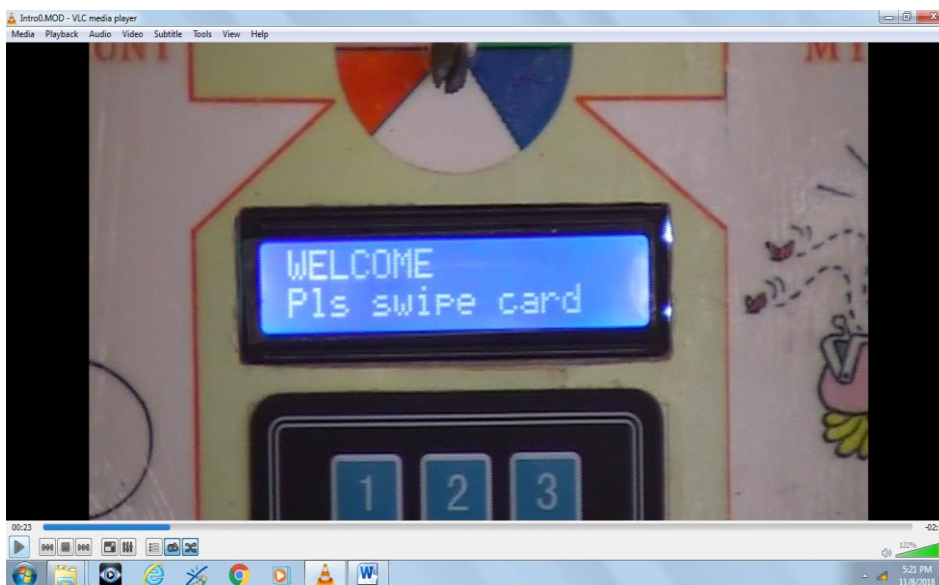


Fig. 8: Machine requesting for Card to be swiped

After swiping the card, the machine displays the customers balance as shown in figure 9.

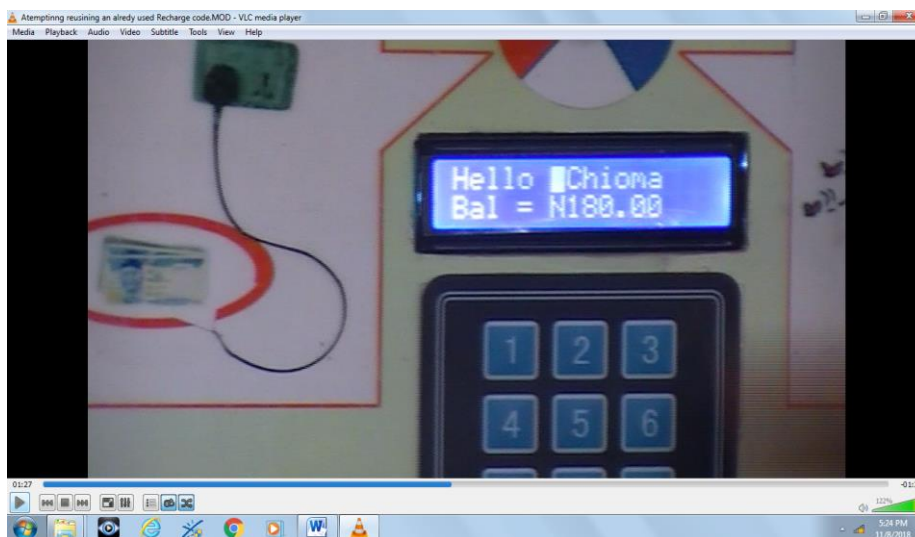


Fig. 9: Vending machine showing the customer's account balance



The machine will request that the user should select the product that he/she wants if the card is well funded as shown in figure 10.

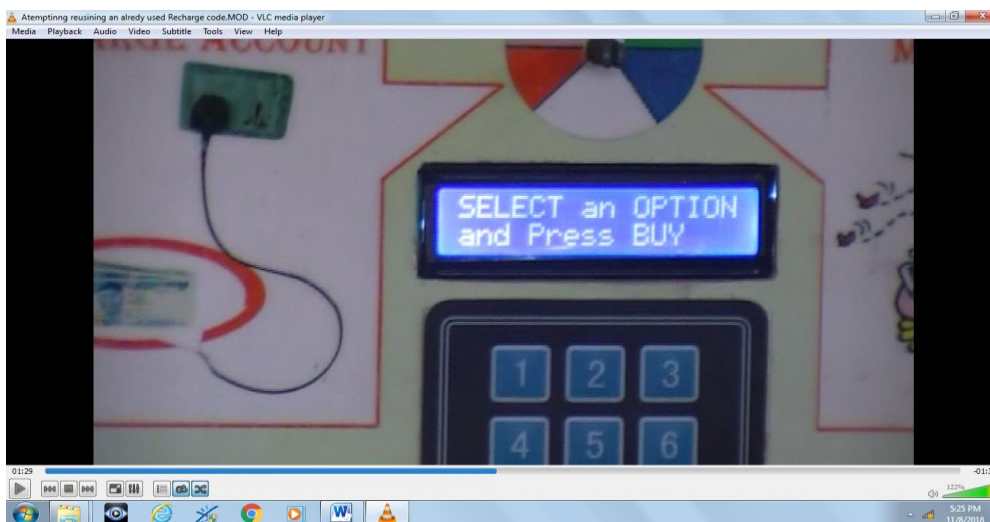


Fig. 10: Specification for Product selection

Once the product is selected, it drops the product from the machine

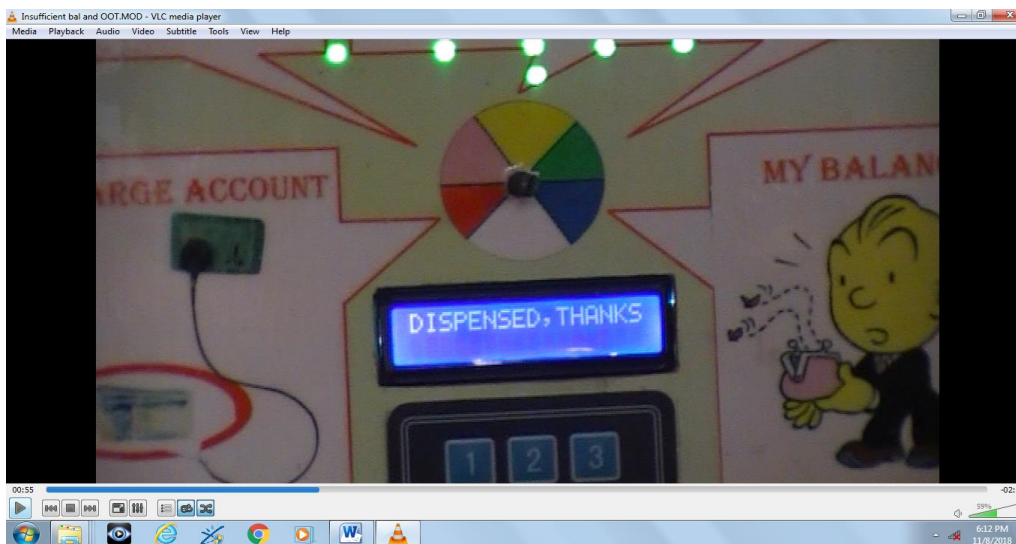


Fig. 11: Message displayed once product is dispensed

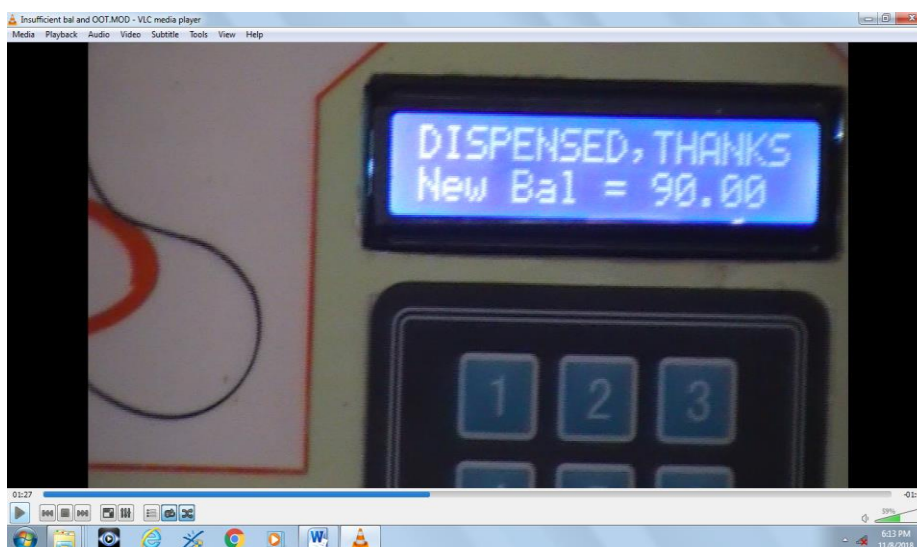


Fig. 12: The vending machine displaying the balance after transaction

To recharge the card, the customer is expected to enter the recharge code as shown in figure 13.

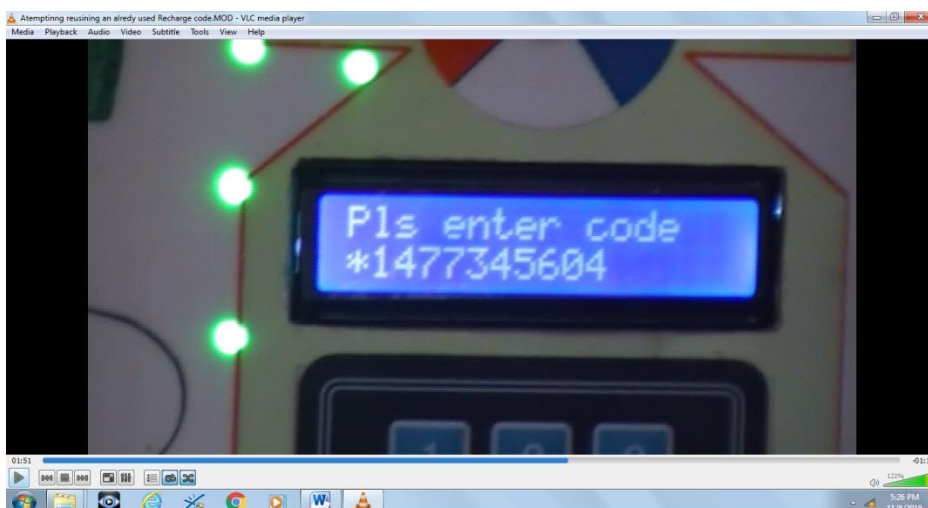


Fig. 13: Specification for Card Recharge

Once the code is entered, machine displays a message showing that the recharge was successful as shown in figure 14. Payment for the recharge is paid to and gotten from a registered vendor.

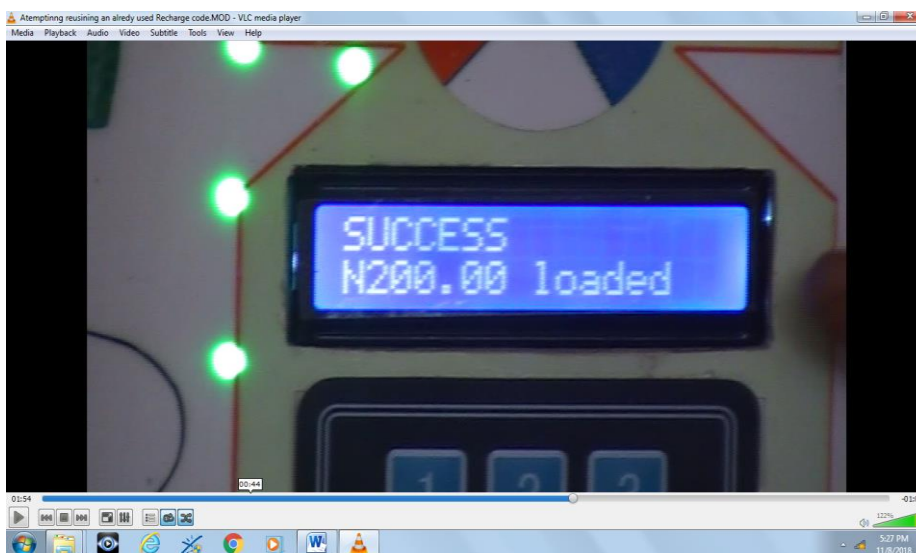


Fig. 14: The Display after card Recharge

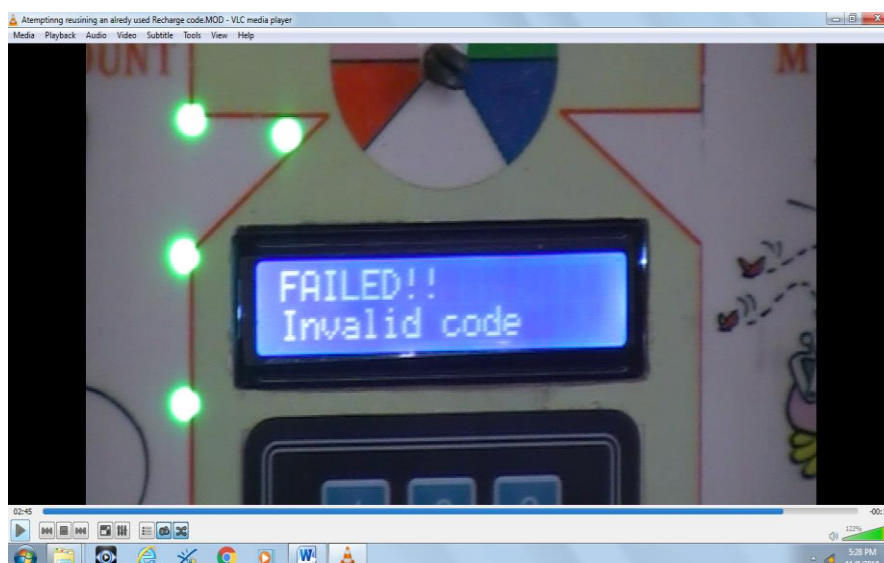


Fig. 15: Message displayed if the card recharge failed

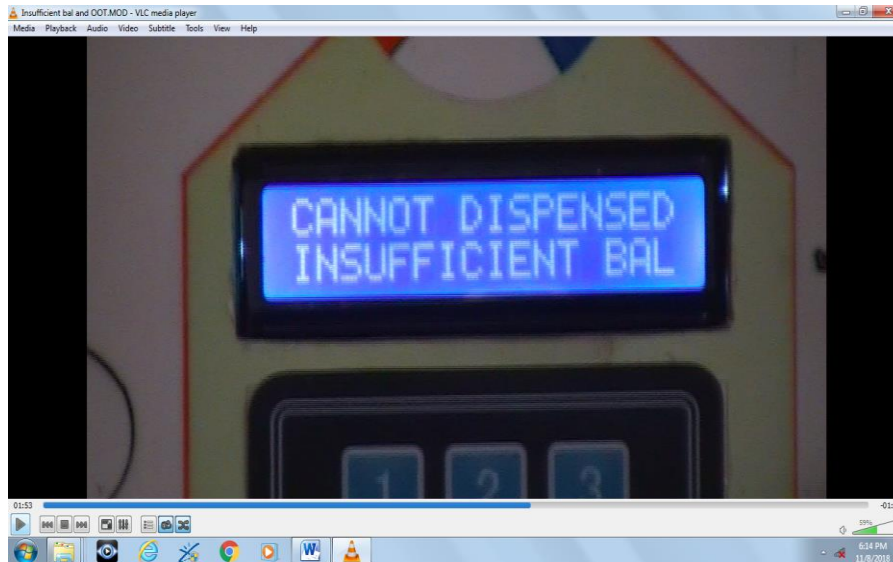


Fig. 16: Message displayed if the card has insufficient balance

### C. Hardware and Operating System Requirement

In system developed, the following are required.

#### ➤ Hardware / Components Requirement

Stainless Steel Sheet Metal and Cast Iron are the basic raw materials that are used for constructing the product. Wood is cut and joined at the edges to enable the container to hold the dispenser and electronic circuit while an RFID reader is bolted to the front side of the container. A power connector is at the back with a door hinged at the top to allow the user to access the dispenser. To implement the vending machine, the following are required:

- Single CH Relay Module
- 2CH Relay Module
- 4CH Relay Module
- 8CH Relay Module
- IR Distance Sensor
- 9g Servo
- 48g Servo
- Bluetooth module
- Arduino UNO R3
- LCD 602
- LCD 2004
- Key pad 4x3
- Buzzer
- Resistors, LED, Diode
- RFID card reader
- RFID card
- Colour Sensor
- Stepper motor

#### ➤ Software Requirements

For easy writing of codes and uploading the code to the board, an IDE Arduino Mega software was used to handle the software programming aspect at the back end with C and C++ languages for the front end.

### D. Detailed Implementation Plans

The vending machine was implemented in phases.

Step one: Design of the circuit diagram

#### ➤ System Testing

The software implementation and testing of crises, non-functional features like speed and robustness were handled at this. Simply, the testing involves executing the software application using sample data in order to be sure that all specific objectives are appropriately met and a high quality and user's friendly application is achieved. The tabulated summary of the obtained result that was achieved at the cause of testing was presented in this section. Each control button on the machine's control software was tested and its effect on the model observed. Table 5 below shows the test and the test result when no fault is encountered.

#### ➤ Performance Evaluation

In this paper, it has been shown that the researcher had a deeper analysis and details about the vending machine technology. It indicates that on increasing efficiency and lower dependency on manpower, the desired outcome can be achieved based on the user's requirements in the form of product dispensed by the vending machine. The technology makes it easy for clients to obtain their desired products instead of waiting on longer queues for hours.

It also brings to our notice the functioning principles of various types of instruments like the functioning of RFID, Microcontroller AT89C51, Motor drivers etc. With all these, our knowledge about the functioning and performances of vending machines were greatly improved. The system was able to validate payment card data before dispensing can take place. Hence the performance of the system can be rated at 95%.

#### ➤ Training

In order for the proposed system to effectively and efficiently function, the need for training of vending machine operators is inevitable. Special training should be conducted for human resources chosen to handle the registration of new cards, printing the recharge codes/cards and placing of products on the vending machine. The selected personnel are trained to be able to manipulate and operate the system for a period of time so that they will be

familiar with the vending machine and the system designed. In other to ease operation, the operators are equipped with procedural manuals to help them achieve success.

## VI. CONCLUSION

An automated Vending Machine for sale of drinks has been designed and implemented in this thesis. An RFID payment system was also incorporated to make the Vending Machine cashless in operation. When this RFID-based Vending Machine is compared with the cash-based alternative, it is noted that the RFID-based has outperformed the cash based in terms of efficiency, security and sales tracking and it is therefore a better machine used for sale of drinks.

This thesis has presented to our knowledge the techniques used to develop an RFID technology based Vending Machine for the sales of drinks. The realised product has an advantage of data flexibility and efficiency and has a better way to manage financial returns of the business. The prepaid card must be funded before it can be used for transactions on the Vending Machine.

## REFERENCES

- [1.] Jaffe, E. (2006). *Old World, High Tech (World's First Vending Machine, scroll down to read. Retrieved from <http://www.smithsonian.com/0okdhg?/>.*
- [2.] Sharma, M. (2014) Implementation of Reverse Vending Machine Based on FPGA: Implementation of Reverse Vending Machine Based on FPGA. *International Journal of Modern Engineering Research (IJMER)*, 47(32), 1-7.
- [3.] Kerry, S. (2002), Vending Machines: An American Social History, *McFarland*, 8(87), 215-860. ISBN 978-0-7864-8159-0.
- [4.] Holcombe, M. (2017). *A vending machine at the UC Davis campus dispenses Plan B pills. Retrieved from <http://www.CNN.com/0rree8/url/>.*
- [5.] Jechlitschek C. (2006), Implementation of Reverse Vending Machine Based on FPGA. *International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)*, 63(16), 39-53.
- [6.] Juels, Salshi S., (2005), *A vending machine at the UC Davis campus dispenses Plan B pills. Retrieved from <http://www.CNN.com/0rree8/url/>.*