



UNIVERSITY of
RWANDA

COLLEGE OF SCIENCE AND TECHNOLOGY



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AFRICAN CENTRE OF EXCELLENCE IN INTERNET OF THINGS

SMART AIRTIME VENDING MACHINE
Case Study: Nyamasheke District, Nyabitekeri Sector
MASTER'S DISSERTATION

Submitted in partial fulfilment of the requirements for the award of
MASTER OF SCIENCE IN INTERNET OF THINGS
WIRELESS INTELLIGENT SENSOR NETWORKING
(MSC in IoT WISENET)

Submitted by

HABUMUGISHA Fulgence - Reg. No. 218015284

January, 2022



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Under Supervision of:

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January, 2022

DECLARATION

I, HABUMUGISHA Fulgence, utterance claim that this dissertation record is my proper work and has no longer been submitted earlier than for any instructional prize in each my college or extraordinary higher learning institutions for instructional book or a few other reasons.

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Signature.....

Date...../ .../.....

BONAFIDE CERTIFICATE

I confirm that the dissertation document titled “SMART AIRTIME VENDING MACHINE” is the real paintings of HABUMUGISHA Fulgence registered to 218015284 in partial achievement of the requirement for the award of a Master’s degree in Internet of Things - Wireless Intelligent Sensor Networking (MSc in IoT-WISENET) from College of Science and Technology at University of Rwanda.

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Date :...../...../.....

DEDICATION

I commit this dissertation.....

*To my wife Angel UWASE and my kids LINDA, RHEEM and LONAN without whom this
dissertation could have been completed.*

To mother and father, who took me to the school!

*To my supervisors, lecturers and near friend, who supported me plenty all through my
master's research!*

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ABSTRACT

The most important intention of this thesis includes undertaking modern technology by designing and implementing a smart airtime vending machine known as a self-service airtime vendor machine that will come as an additional method apart from the current airtime selling and buying methods which are mobile money, banking, airtime agent that involves a lot of issues and risks like theft of money and airtime loading mistakes and errors. It will help rural citizens to buy airtime using a coin where a customer has to enter the mobile number using a keypad then inset coin in airtime vending machine, and automatically the machine dispenses the airtime equivalent to the amount inserted.

The proposed methodology consists of an IoT system where the customer will access the vending machine by inserting it into a coin to buy airtime. This research consists of three main parts, the first part is the interconnection of IoT hardware components that build the entire circuit and are linked to the cloud via GPRS/GSM communication technology, this part involves sensing components, data processing components, and actuators components. The second part consists of coding using Arduino IDE that makes IoT system hardware operational and the last part is data processing and analytics using python programming and regression as a machine learning technique. The system monitoring is done through wireless radio, the cloud data storage is secured and can be easily accessible by authorized users via a web interface. The battery is used for powering the system and the solar panel for recharging the battery. All transaction data are recorded and given date returns the day type between working days, weekends, and the session of the day.

The expected results of this research include an IoT system that is developed and implemented to help both airtime agents and customers to sell and buy airtime using coin-based self-service airtime vending machine and the model that analyse machine transaction data using Python programming and regression as a machine learning technique.

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LIST OF ACRONYMS

IoT: Internet of Things

NFC: Near Field Communication

ATM: Automatic Teller Machine

NAMA: National Automatic Merchandising Association

PSI: Population Services International

RBC: Rwanda Biomedical Centre

RFID: Radio Frequency identification

EPROM: Erasable Programmable Read-Only Memory

VM: Vending Machine

LCD: Liquid Crystal Display

SAVM: Smart Airtime Vending machine

DC: Direct current

SOA: Service-Oriented Architecture

ERD: Entity Relationship Diagram

DFD: Data flow diagrams

WISENET: Wireless Intelligent Sensor Networking

GPS: Global Position System

GPRS: General Packet Radio Service

GSM: Global System for Mobile

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Several merchandising machines dispense snacks, biscuits, and beverages while money is inserted according to pre-programmed. Nowadays vending machines offer many extra things to customers. As these machines are connected with IoT networks, they're called clever vending machines. Using such smart merchandising machines, customers should purchase clothes, items, vegetation, luxurious vehicles, and so forth. IoT-primarily based machines help stores promote their merchandise across the clock and provide more comfort to purchasers. Vending machines are established on street corners, railway stations, airports, outdoor offices, and so forth. The machines include virtual presentations, which offer interesting reviews to customers [1].

Smart merchandising machines are incredible examples of the impact of the Internet of Things (IoT) on revenue streams and commercial business enterprise fashions. With progressed protection, individual customization, smart payments, and normal monitoring of inventory and intake styles, opportunities abound for allotting new products more profitably the usage of a network of linked devices.

A tremendous shift, almost 100 years after merchandising machines the first deployed, conventional vending machines have superior technology to embody more virtual talents, turning them from dumb terminals into smart, linked gadgets [2].

New reference layout for sensible merchandising offers a smooth manner to retrofit conventional vending machines into net-related machines. Brands and machine operators can take advantage of recent company possibilities, cloud services, and facts analytics through a suite of associated products and packages. Here are five examples of the manner IoT contributes to vending gadget industry to enhance financial returns with improved revenues, improved profitability, and a higher patron revel in Digital content material cloth delivery; Intelligent software program solutions permit the shipping of virtual content material to every show display screen of a vending tool, with extra impact vending machines can act as billboards, imparting custom content, inclusive of promotions, movies, video games, and TV classified ads on a unit's touch display. By putting these machines at immoderate-web page site visitors net websites, like stadiums and theatres, businesses can create an immediate connection with consumers. This enables manufacturers reach unique audiences proper away and allows the brand to remotely manipulate messages in actual-time and launch custom designed content material dynamically. This additionally helps generate new assets of content

fabric and marketing revenues that might be allotted some of the system operators, the venues, or any entity that controls the power where the machines are stationed [3].

Smart billing; Users will pay for objects using near field communication (NFC) bills, a credit score/debit card, or one-of-a-kind cell wallet apps. Coke has advanced its cashless gateway to decrease transaction expenses and growth manage over overpayments. Consumers also can use mobile wallet rate structures collectively with Google Wallet, a downloadable cellular app, to faucet smartphones in competition to merchandising machines readers to make purchases with one swipe. This affords new assets of sales for the rate structures as well as gives a higher customer revel in, which in flip can growth utilization and customer loyalty.

Social exchange; Smart vending answers offer producers the opportunity to interact with their customers in highly personalised methods. Consumers can use smartphones to come to be aware of themselves, build profiles, connect to their social networks, play social video games, and achieve promotions and tailor-made commercials. Social interplay through gifting permits customers to deliver provides to their pals. Gifting happens even as clients enter their social media money owed for recognition and pick out a recipient, which allows for the merchandising gadget to ship a notification message to the buddy, collectively with a code that allows the recipient to choose up the present at a participating vending system. Vending machines can also utilize gamification to get human beings to test-in and have interaction, developing common person engagement. For instance, Coke is affixing QR codes to its merchandising gadget to inspire customers to create avatars, check in to machines often and receive rewards which includes avatar digital gadgets [4].

Inventory management; Machines the usage of sensor statistics and built-in intelligence can make the proper stock selections. Connected structures allow manufacturers and distributors to song shipments to distribution centres and vending machines, in addition to accumulate client records from machines to screen utilization for correct consumable resupply, track income traits by means of geography and time of year, and remotely troubleshoot system issues. The software program combines the carrier and stock alerts with income facts so agencies can dispatch their provider humans to the most profitable machines first.

The tool additionally makes smart inventory alternatives primarily based on the facts it has accumulated from the vending system and all of the others owned with the aid of way of this commercial enterprise organisation, similarly to information from outside property. For example, honestly because it's low on ice cream could now not mean the device will place orders for greater ice cream not if the weather is meant to be bloodless for the subsequent numerous days. It additionally takes into consideration other elements, which include

popularity, while putting stock levels, so the right quantity of each snack is added to the truck for transport each day.

Maintenance and energy savings; Device control applications allow carriers to remotely discover, diagnose, and restore machines. Coca-Cola unveiled a really-energy-saving merchandising device in Japan that cools beverages down at night time yet continues them cool within the sunlight hours with hermetic doorways and vacuum-insulated fabric. Peak time power conservation permits carriers to manipulate and shift power used to chill liquids from day this night. This makes it possible for the machines to offer bloodless merchandise without the use of any electricity, slicing daytime strength intake. Such structures present endless opportunities for the vending organization to maximize productivity and profitability [5].

1.2 Back ground and motivation of the study

The first vending device have become constructed thru Heron of Alexandria (Mechanicus, about one hundred BC). After setting a coin, holy water modified into dispensed. For extra than 100 years' humans had been capable to buy items and services from merchandising machines.

The first commercial enterprise vending machines had been built on the surrender of the '80s of the 19th century. On thirteen March 1908, the primary stamp and postcard-merchandising device of the world were established inside the front of the Hotel des Postes. Vending machines are utilized in exquisite markets, inside the retail alternate for the selling of meals and non-food devices as well as consolation products.

Selling bloodless and warm drinks changed into the number one business enterprise inside the past, however at gift, the kind of items and services advertised with vending machines is steadily increasing. ATM (Automatic Teller Machine) is that the exceptional example of era evolution in phrases of slot machines in an engineering problem. ATMs reduce the time and human efforts required to appearance, understand and alternative a queue for coins' bills or maybe for cash withdrawals [6].

Vending Associations in unique international locations outline vending in every other manner. Vending is defined due to the fact the promoting of merchandise via vending machines, which might be "coin-operated machines for the sale of small articles. Additionally, merchandising machines may be designed for the sale of massive portions of various products, e.g. In Japan, one should buy ten-kilo baggage of rice from a vending tool.

Furthermore, for a couple of years, it's been viable to pay for items and offerings via credit score rating card which must be placed in the vending device's slot for playing cards.

The worldwide vending gadget market period modified into well worth USD 30.30 billion in 2018 and is predicted to test in a CAGR of 9. Four% from 2019 to 2025. Growing name for on-the-cross snacks, beverages, and so on. Because of a hectic way of life is boosting product profits [7]. The increase additionally can be attributed to the tool's capability to supply items quick making it an in reality convenient desire for customers. Based at the utility, the merchandising system market is segmented into business places, places of work, public places, and others

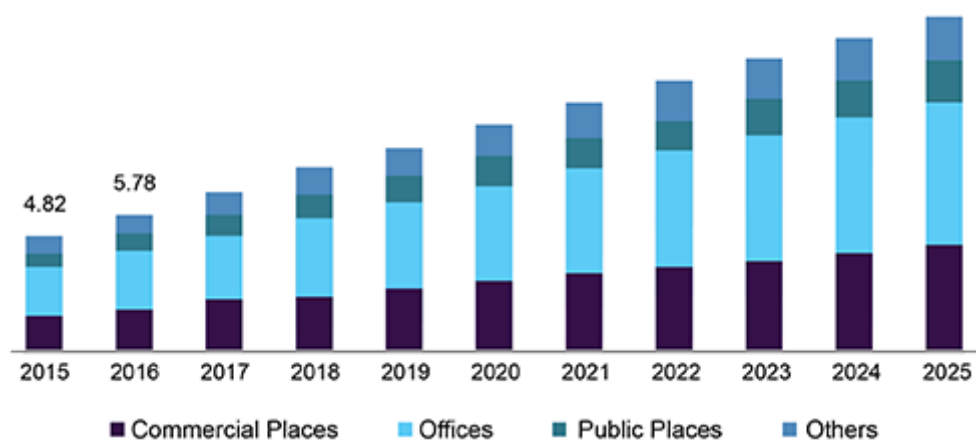


Figure 1: Vending Machine Market Size, through application,2015-2025(USD Billion)
Source [7].

Technological enhancements, alongside Cashless bills, Smartphone interaction with Artificial Intelligence, Energy-Saving Vending, face and voice reputation, Self-Inventory, and massive facts integration, making the product less hard and handier to apply can also actually have an effective effect at the decision for. With such upgrades, vending machines can now supply custom-made meals devices, salads, and so forth. Other than warm and bloodless drinks. For example, in 2018, Pizza Deli 24/7 introduced a pizza vending device that gives pizza in five flavors [8].

Based on charge mode, the market is segmented into cash and cashless. Cash fee mode is anticipated to be the most important phase over the forecasted duration as most of the people of the prevailing merchandising machines have coins due to the fact the quality price alternative as set up of gadgets providing cashless alternatives is especially luxurious. However, variable pricing fails in merchandising machines with coins as charge mode acts as a top restraining element for the section increase. Machines with cash as fee mode acts as a top restraining issue for the section boom

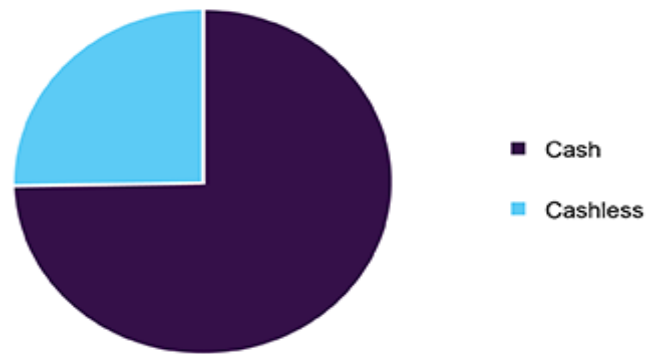


Figure 2: Global Vending Machine Market, by Payment Mode, 2018(%) Source [8]

Thus, the cashless price mode section is estimated to witness the quickest CAGR over the forecasted length. Also, many manufactures are partnering with several payment carrier businesses to meet the developing demand for cashless rate options.

In America, the American Association NAMA (National Automatic Merchandising Association) states that "vend is the delivery of a unmarried unit of products". In the USA, vending is relatively associated with the slogan "Coffee, Candy, Cola "eight. "Coffee" symbolizes the sale of heat beverages like espresso, warm chocolate, tea, however additionally soups; the term "Candy" represents sweats, and "Cola" replaces the enumeration of different smooth drinks. In the very beginning, the vending enterprise started out with the four- Cs-idea, espresso, cup soda, candy, and cigarettes, and afterward the variety grew to almost eight Cs -coffee, candy or confections, chips, cold drinks, canned liquids, cigarettes, bloodless cup, and commissary [9].

In Europe vending consists of a mile wider range of merchandise (EVA, European Vending Association) The Vending Association in Germany (BDV, Bundesverband der Deutschen Vending Automaten- Wirtschaft e.V.) defines merchandising as the promoting of regular requirements, in particular food and drink thru vending machines. Producers of machines, operators, and specific associations use the term merchandising for all forms of food and drink; however, they encompass non-meals products as properly.

In Austrian, the Austrian Association (ÖVV, Österreichische Verkaufsautomaten Vereinigung) defines all machines that sell goods, which include food, liquids, snap shots, parking tickets as vending machines; however, copying-machines, phones, lockers, washing-machines, pinballs, slot machines, and many others. Also are covered. The BDV excludes machines that provide enjoyment features from the merchandising enterprise. From an advertising point of view, merchandising machines are described as a shop format of the retail exchange industry with an automated selling process the purchaser has to pick the

product, to take it with him/her and to pay for it, the whole lot is accomplished through him/herself.

In Asia, the Asia Pacific Vending Machine Market is anticipated to witness market growth of 17.6% CAGR at some stage inside the forecast duration (2017 - 2023). The vending machines are portable automated machines that dispense remarkable products while cash is inserted [9]. Developing international locations have discovered merchandising machines which may be very to be had to apply. Vending tool technology keeps to offer the modern-day enhancements like face reputation structures, ID card identity to check the looking for facts of clients, thereby ushering a generation of technologically superior vending machines. The crucial nations inside the Asia-Pacific region embody China, Japan, India, Australia, Singapore, Taiwan, and others.

In UAE, merchandising machine marketplace is predicted to sign in extensive increase over the approaching years in most instances because of the emergence of a massive huge form of food and beverage players, rapid urbanization, and changing lifestyles of clients. In phrases of product type, the vending device marketplace in UAE is segmented into liquids, snacks, candies and candies, tobacco, and others. The snacks and beverages category collectively dominates the general merchandising gadget market profits in UAE because of the busy manner of lifestyles and changing opportunities of purchasers [9].

In Africa, merchandising system market is expected to check in extensive boom over the approaching years mainly because of the busy and disturbing life-style of humans as well as the growing running population within the place. Additionally, digitization and growing call for ready-to-devour food and beverages along with a developing quantity of supermarkets and retail chains will similarly spur the call for merchandising machines in Africa. Moreover, using vending machines in recent times isn't always handiest constrained to offer primary and household commodities to customers however the vendors are also presenting medical products for instance, in 2019, South Africa has introduced a revolutionary device to dispense drug treatments to sufferers affected by persistent illnesses to keep away from the lengthy queue of patients in hospitals and clinics [9].

Based on quit-clients, the vending machine market is segmented into QSR, purchasing branch shops, & retail stores, offices, and establishments, public shipping, and others. The QSR, purchasing department stores, and retail stores are witnessing widespread growth within the merchandising device marketplace in Africa. Additionally, in phrases of product type, the merchandising tool marketplace in Africa is segmented into drinks, snacks, chocolates & sweets, tobacco, and others. The snacks and liquids class ends inside the general

merchandising system market income in Africa because of the busy lifestyle and the rising quantity of the going for walks populace. Further, the drugstore stores also are recording vast increase in sales because of the spread of the Covid-19 pandemic which has ended in accelerated usage of merchandising machines at some stage in hospitals and different healthcare facilities. The Africa merchandising gadget marketplace record comprehensively covers the market with the resource of product types, end-clients, and key international locations which consist of Kenya, Nigeria, Egypt, South Africa, and the Rest of Africa [10].

In Rwanda, merchandising machine market isn't always waiting for to check in high boom during the last years however shows the wish of growth in coming years basically due to the busy and stressful way of life of humans in addition to the growing operating populace within the United States of America. Additionally, digitization and developing call for for ready-to-eat meals and beverages together with a growing range of supermarkets and retail chains will in addition spur the call for merchandising machines in Rwanda.

Based on end-customers, the vending device marketplace in Rwanda is segmented into purchasing (Inyange Milk Vending Machine), banking (ATM), public delivery (Tap&Go), bars, motels and public area (Condom Dispenser Machine). And others are in entrainment region (Gaming Machine named Ibiryabarezi). Some of these vending machines are no longer operational just like the Milk merchandising system (for Inyange) and condom dispense machine (Ministry of health, PSI &RBC) [11] .

For condom vending machines, Population Services International (PSI), a non-profit social advertising organization primarily based in Washington DC, and the Rwanda Biomedical Centre (RBC) to begin with installed approximately 60 merchandising machines in several hotspots in Kigali and later installed 690 more machines. A new scheme, dubbed the “24/7 Condom Distribution Kiosks Initiative”, includes the strategic placement of “condom kiosks” or CVMs in four HIV excessive-hazard areas in Kigali [12]. The authority’s initiative, in partnership with the AIDS Healthcare Foundation and the City of Kigali (CoK), is part of a broader effort to manipulate HIV spread through safe sex practices, emphasizing geographic hotspots and high-threat agencies, consisting of lady sex employees (Kantengwa, 2016).

Effectiveness: Newspaper survey studies suggests that many CVMs at hotspots and motels in Kigali are both run down or idle due to a lack of condoms (Kantengwa, 2016). Stock tiers in a few accommodations were located to be “inconsistent” because the machines are handiest “filled from time to time”. This shows that the capital’s population are nevertheless at high chance of HIV [13].

For Tap&Go as a made from AC Group Ltd, is a start-up generation firm in Rwanda's capital, Kigali, and released in December 2015. Is a leading issuer of interactive and sensible public transportation solutions, Issuer of payment playing cards in manual of a cashless financial system, and regional expansion with the cause of building a nearby ICT Hub.

Tap and Go card is used to pay for bus tickets by using taping on the cardboard reader on the bus access, the passenger loads the cash on the cardboard earlier than the journey on the agent or they're capable of reload their card with their Mobile cash machine to enhance the cashless monetary gadget and smart delivery.

Using Tap&Go card for rate, a bus validator at the bus for validating price, automobile vicinity, pace tracking, and fraud manipulate. Today Tap&Go is being used in Kigali and Yaoundé with over 670,000 clients consistent with day. Tap&Go the companions are World Economic Forum, Government of Rwanda, Kigali Bus offerings, RFTC, Royal Express, Government of Cameroon, STECY, DMM.Com, and Transform Africa.

For Milk vending tool as a made of Inyange industries Ltd, In February 2012 in a bid to enhance the great of milk and meat its excessive call for, Inyange Industries, the use of the united states's largest meals processing employer, introduced a milk merchandising machine. It allowed consumers to get admission to processed milk at a low price the use of a coin of 100 Frw. According to a declaration from Inyange, the merchandising machines had been strategically located with the agency's new distributors allowing clients to buy a few things quantity they desire the usage of their private containers [14].

Once operational, the purchasers can be capable to shop for processed milk at Rwf400-450 "which gives a better possibility to shopping for unprocessed milk locally called (Amasukano) at Rwf 300-350 which has no value addition and nonetheless poses a huge fitness hazard to customers," the statement study. The development comes after supermarkets and stores across the United States currently complained of a scarcity of pasteurized milk from Inyange Industries, main to a hike in expenses. The scarcity has become attributed to disagreements a number of the dairy farmers and Inyange; the farmers claimed that they have got been getting little cash for their milk.

The milk vending machines that Inyange has to this point added are three in usual; one modified into located at Kisementi in Remera, the alternative at City Plaza in Kigali town, and at the zero.33 one in the new Kigali City Market. The subsequent step in three months' time modified into to introduce five greater machines which have to be observed via mobile automatic milk merchandising machines although in the pursuit to growth accessibility and affordability of milk to purchasers.

Automated teller machines (ATMs) in Rwanda have been stated at 5.04 ATMs in 2019, in step with the World Bank collection of improvement symptoms, compiled from formally diagnosed resources. Rwanda - Automated teller machines (ATMs) - actual values, historical data, forecasts, and projections have been sourced from the World Bank in July of 2021 [14]

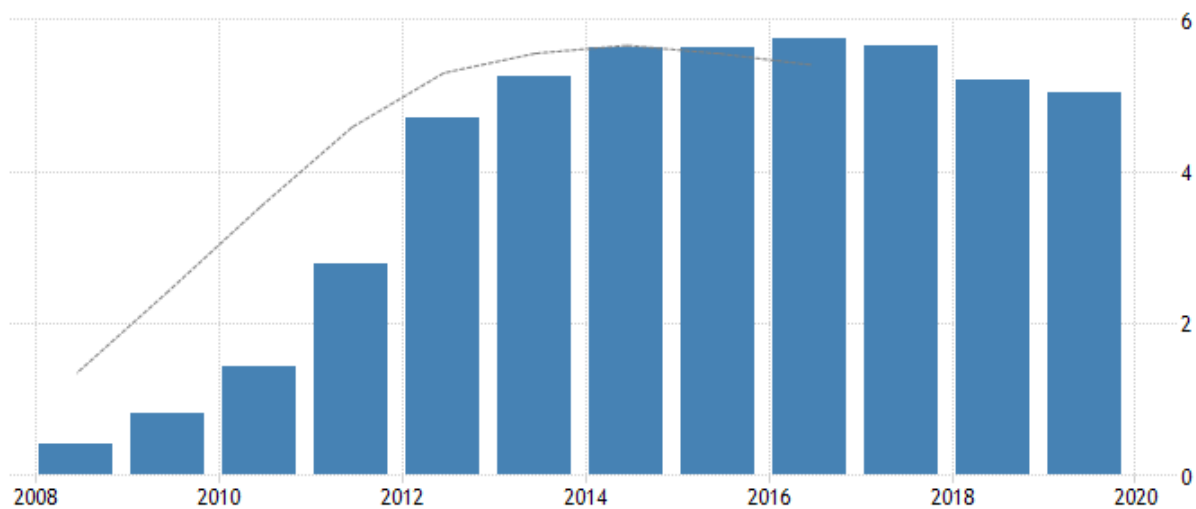


Figure 3: Rwanda - Automated Teller Machines (ATMs) - Actual Values, Historical Data, Forecasts and Projections up to 2021. Source [14]

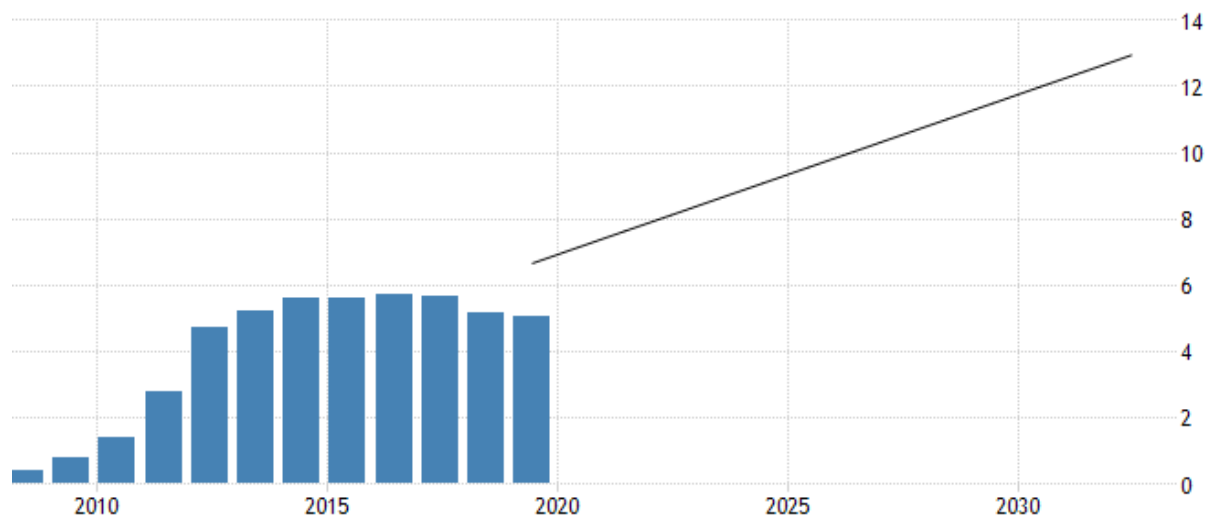


Figure 4: Rwanda - Automated Teller Machines (ATMs) - Actual Values, Historical Data, Forecasts and Projections up to 2036 [14].

1.3 Problem Statement

The number of customers buying airtime in the village is less than in urban areas due to the fact people's financial status is low and most rural citizens do not possess mobile phones. This results in a low-income generation by airtime agents. Therefore, business sustainability is not feasible and airtime service becomes an additional product of the other existing business. Being that it is not the main product, customers of the same service spend much time looking where to get the service and waiting for it since most of the owners of the boutique are busy with main products. They are some airtime agents that misbehaving in providing airtime which is not equivalent to the paid amount, such conduct may due to the human being mistakes himself or human errors. Another challenging issue is to make a model to learn from transaction data recorded to predict the future amount to be generated by the vending machine based on different machine locations and this analysis will indicate if the machine is needed in a specific location. Study objectives.

1.4 Research objectives

1.4.1 General objective

The research aim is to develop an IoT based Smart Airtime Vending Machine that helps rural citizens to buy airtime using coins where they have to enter the mobile number using a keypad then inset coin in the vending machine, and automatically the machine dispenses the airtime equivalent to the amount inserted and also to analyse machine transaction data using Python programming and regression as a machine learning technique

1.4.2 Specific objectives

- To design and implement the smart airtime vending machine
- To train the machine on the coin to be used and top up airtime with provided money
- To analyse machine transactions data from a specific location using regression as a machine-learning algorithm.

1.5 Research questions

- How can a smart airtime vending machine be designed?
- How the machine does recognize the coin to be used? and why?
- How do you model the airtime vending machine?

1.6 Study scope

The scope of this research is to design an IoT system and develop a prototype system that helps rural citizens to buy airtime using coins where they have to enter the mobile number using the keypad, then inset coin in a vending machine, and automatically the machine

dispenses the airtime equivalent to the amount inserted and also to analyse machine transaction data by building a model to predict the amount dispensed using recorded data. Technically the system designed combines the technologies of Coin sensor, IR sensor, GPS, and Servo motor that are controlled by Arduino mega as the control unit and connected to the remote server through GSM/GPRS technology. The system can top up airtime and send notification SMS to the customer's mobile number. The system can provide interaction with users through the web and store its data to the cloud on the server-side.

1.7 Significance of the study

The availability of vending machines may be very vital because many people depend on them to get entry to services and products comfortably at any time of the day, they may be generally used to dispense special services and products like Candy, liquids, meals, and other consumables that don't require an income person's presence. Considering our case of merchandising airtime, I observed this study having a large way to distinct telecommunication groups (MTN, Airtel & Tigo) as well as the airtime agents or airtime sellers because the vending machine reduces the time taken by the customer to look where to buy airtime, eliminates airtime sellers or agents misbehaving, mistakes and errors which impact negatively the business of selling airtime and eliminates poor service delivery to airtime customers. Also, this study helps in making a model to learn from transaction data recorded to predict the future amount to be generated by the vending machine based on different machine locations, and the results from this model will indicate if the vending machine is needed in a specific area or not.

1.8 Anticipated Outputs

The expected output of this research includes but is not limited to the following, An IoT system that is developed and implemented to help both airtime agents and customers to sell and buy airtime using coin-based self-service airtime vending machine. The research aim is to develop an IoT system called smart airtime vending machine that helps rural citizens to buy airtime using coins where they have to enter the mobile number using the keypad, then inset coin in airtime vending machine, and automatically the machine dispenses the airtime equivalent to the amount inserted and analysis of data by building a model to predict the amount dispensed using existing recorded data.

1.9 Organization of the study

This book incorporates six chapters, chapter one which is the introduction includes the historical past and motivation of the study, assertion of the problem, have a look at

objectives, research questions, and observe scope, the significance of the study, and organization of the take a look at. Chapter two titled literature review that explains the prevailing literature, what the gaps on this literature are, and how the gaps are going to be solved. Chapter three is a research method that explains the methods used within the implementation of the mission and has to lead to a clear implementation plan.

Chapter four which deals with system analysis and design, explains the system model, proposed simulation models, simulation parameter, and simulation scenario. Chapter five which result and analysis, explains the findings and the graphs of the results, the last chapter is the conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The reason of this bankruptcy is to set up scholarly significance of the research trouble with the aid of the use of manner of showing previous research within the region, to enhance my very own know-how within the area to find out an opening within the literature and the want for this research [15].

2.2. Related Review

Nowadays, various research has been done about the vending machines to advance or renovate the vending machine system. A real-time vending machine and a cost affordable communications solution based on open innovation technology is designed [16]. Wi-Fi and GPRS are introduced inside the vending machine with the goal that the information about the stock level can be stored in a database which can help make informed decision or refilling the machine with new stocks. Likewise, Mealy Model of “Finite State Machine strategy” is utilized to structure and implement an automated beverage vending machine[17]. They presented field programmable gate array (FPGA) based vending machine which consumes less time and utilize less power when contrasted microcontroller based with vending machine. In addition, vending machine payment had changed a lot. In the early stage, payment system uses cash or coin[18]

This machine faces a trouble if there is a confined area to keep the cash and deliver modifications. A new design of an automated vending machine is proposed through the use of quick message fee. It may additionally confront a difficulty in the event if they fail to obtain a message [19].

Yogesh R, A, S.W, A.B, M. B, P, [2017] Proposed smart milk merchandising system thus inside the milk canners there can be a massive queue to gather milk because milk desires to be measured and additionally has to gather the cash [20]. So, to forestall the equipped time in the queue and paying cash via hand, the RFID reader can be applied in milk canners. With the assist of go along with the flow sensor, we are able to diploma the go along with the glide of milk via microcontroller, however a person continues to be required to gather the coins.

To get rid of the human involvement a card device is used for merchandising or for shelling out the milk. The card gadget consists of the RFID which encompass RFID reader and RFID tags that may be helped to the customers at the milk canners [21]. The card used to recharge

due to the fact it's miles prepaid tags. Using this tags milk may be vended without human interaction or involvement.

They have studied many papers concerning this, in reference, paper [22] furnished a gadget a clever merchandising system includes a sensor and actuator network, which incorporates of a gateway, environmental sensors, and controllers. A gateway turns into an extension among the community and a software taking walks on a cell phone via Bluetooth. The gateway gets some messages associated with the environmental situations of the machine from the sensors. Those messages are sent to the software. In addition, the gateway sends manipulate messages inclusive of the customer's desire on the taste of espresso to the controllers. They concluded that the proposed device is format to provide fast response serving, to solve real time problem. The improvement of the overall performance and design value changed into considered [23]. Using this device design, the overall performance of Vending system can be without problems extra superb for masses applications. Complexity discounts that incorporate with the time and place boom the performance of the overall gadget utilized in vending machine. Also, we are going registered database of the purchaser through reducing human interplay. The destiny paintings of this vending machine are to enhancing it by using which include toll unfastened variety in case of any failure.

Also, we recommend that the system layout a good way to get hold of ATM playing cards as opposed to paper money. Also, improving efficiency and complexity discount of the device may be viable as a way to transform the Vending gadget to a wise method [24].

Rahul, M J, P, H,C,[2017] Proposed clever coffee vending device the usage of RFID [25]. Automatic ordinary espresso merchandising device such as coffee powder or coffee beans, sugar, and milk powder saved in chamber. It also includes the recent water chamber wherein the water is heated. After giving command thru a switch the gadget, add that particular quantity of components in the heat water. Then it is delivered within the cup. The controlling mechanism like heating is executed by way of way of the use of microcontroller. This undertaking makes a speciality of automated espresso merchandising gadget the use of the Arduino controller and RFID era that is used to govern the intake of product and additionally reduce the waste of product in low budget and gives the historical statistics in EPROM [26].

Zhen Lei Yang, Ling Yun Zhao, Liang Tian Gu, 2015 Trans Tech Publications, Switzerland, In The paper the writer has recommend the format of the coffee merchandising machines based totally on the technology of internet of things and its far off control system [27], this is specializing in present day problems happening in present device alongside issues in analysing facts and actually high fee of management. This design now not only makes the

sales and supply statistics to be had, it can survey this data into cloud corner thru GPRS as well [28].

Kwangsoo Kim, Dong-Hwan Park, Hyochan Bang, Geonsoo Hong, and Seong-il Jin

This paper specializes in how technology make contributions to making each day lifestyles be extra reachable. A lot of human beings purchase espresso from coffee vending machines and that they don't even recognise how smooth they are or if they're without a doubt smooth or no longer. So, to recognise the cleansing reputation of those machines, they've got advanced a sensor and actuator network and set up it inside a vending device. The community video display gadgets the indoor environment of the system and adjusts the taste of coffee in line with the choice of the client. A purchaser makes use of a phone to look the environmental information in addition to to control the amount of all of the components of espresso which includes coffee, sugar, and powered espresso creamer [29]. The machine and the telephone exchange their facts via Bluetooth. This device helps the better personalised company.

In previous vending device tool is processor or microcontroller primarily based merchandising system used for whole processing and moreover it has complex coding. This include the sensing of the reception of proper foreign money coin via the coin inlet, identifying the variety of product to be introduced, putting the electrical motor to supply precisely the variety of product, to be added. But the disadvantage of this system is that if the insertion of fake forex coins in the forex collector couldn't be prevented, although product now not added for them. The coin sensor senses the density and size of the coin. It is feasible to get entry to the product by means of placing faux coins with the material of identical density and length [30].

In the 19th century, the primary merchandising device to be efficiently commercialized thru Thomas Adams have become used for the sale of their chewing gum in underground stations of New York. Only in 1902 the primary enterprise agency of merchandising machines emerged, Horn & Hardart Baking Company in Philadelphia. In turn, the Committee Definitions of the American Marketing Association define merchandising machines as "retail income of products or services via jogging machines which can be used by stop clients" [31]. Market superior through computerized vending machines has grown fast considering its miles reachable, quicker and cheaper. According to records, the vending machines emerged inside the 50s due to the truth that earnings decreased and managers needed to reduce costs. They concluded that would store cash via the use of automated machines. The vending machine additionally had a vital function within the new economy of America, being a generator of Employment [32]. Yet there is some vulnerability in this shape of company. When the

financial gadget is in recession, income of this enterprise moreover reduced (LEE, 2003). For example, the intake of merchandise from vending machines decreased with the resource of 5% in 2001 due to the financial downturn (National Automatic Merchandising Association, 2002 and 2003). Nowadays, vending services embody a massive extensive variety of products which include espresso, beverages, snacks, books, toys and different products positioned in stations, schools, universities, companies and hospitals [33], pointed out an issue, absolutely declaring that isn't always viable to serve a “whole meal” in a merchandising gadget.

Regarding the evolution of the merchandising machine itself, inside the ‘30s, there was the coin changers’ improvement. Also, in the ‘30s, small refrigerator turned into located inside the vending device, which allowed the sale of chilled liquids and ice cream at aggressive prices compared to income in shops. In turn, in the 50s, the automatic coffee machines expanded to numerous small groups. Its smooth appearance and delightful layout might be appropriate in cafeterias or classrooms. In the ‘60s, producers have added machines with the hypothesis of automated observe changers. In 1961, one million and a half of the U.S. Population supplied at the least one product within the merchandising machines each day [34].

Regarding the performance of VM, many researches have been investigated the structure of the VM. Fauziah Zainuddin [35] proposes a VM, which has the simple methods of FSM for serving meals in suitable way. Here, the researcher used three specific functions in his design they will be individual preference kingdom, freezer u . S. A., and steaming nation.

There are some of researches that analyse the format of VM. In [36] they advocate FPGA board VM, which give to people 4 products, especially, Ice cream, Coca-Cola, snacks and chocolate. Using very simple steps and layout, efficiency may be advanced to supply the product. The gadget takes a best coin, types of coins (one rupee and rupee). It offers the alternate relying on the amount of cash that the customer has inserted, and there's a Cancel button to head returned the coins to the person. Using Xilinx, State CAD device does the VM simulation.

In [37] they advocate multi-choose VM, that's the Mealy version wherein the design of FSM is taken into consideration. The performance of VM may be improved using optimized coding written in VHDL language and carried out in FPGA board. This VM has 4 product milk, water, fruit, and sprite. It takes only coin two forms of coin five rupee and 10 rupees. It has vehicle billing and cancel features. Here, Xilinx ISE simulator does the VM simulation.

According to the studies paper [38], authors have defined a concept of automatic fee price ticket VM with the resource of the use of the sensor, RFID, and Zigbee approach. Here, they have got used the automated device wherein humans can use the clever playing cards that are a great deal clean to deal with in the course of the rush times. Also, it gives secure environments due to the fact every transaction is monitored and stored for all future identification. The devoted VM used for purchasing tickets has LCD that is the one of the smart capabilities in the modern-day VM. Through this LCD, the humans can see the data of the journey time and destination that humans have deliberate to go to. The automated tool enables us store the pointless price and time [39]. Also, it encourages us to boom the overall performance as it dreams less complexity.

In the ones contemporary days, Reverse VM may be very well-known in an unmarried-of-a-kind international location. It saves time and power of the device that increase the overall performance of VM. According to [40] we are able to describe the Reverse VM that works on the identical time as placing the empty beverage vicinity into it. The task of Reverse VM (RVM) is vain without the cooperation of the patron. The best example of RVM is refund operation that is the one of the essential capabilities in the VM.

2.3 Literature Gaps

After analysing the global vending machine market especially in Rwanda it appears that vending machines have been used in many different businesses such as buying, public shipping, banking, bars and resorts, and others to supply beverages, snacks, sweets and candies, tobacco, and others however it's far clean that the shortage of merchandising machines that promote airtime is identified and these merchandising machines have in no way been used at everywhere and that seems like a large gap in this region of business being made the usage of vending machines, my cause is to bridge this gap by means of layout and enforce a self-service and coffee value-effective coin based totally vending device which can pinnacle up airtime particularly for rural citizen. This vending machine can be placed in public areas like markets, schools, construction sites, mining sites, village centres, and other places where getting airtime seems to be difficult. Finally, the data generated by vending machine will be stored on a remote cloud server and will be analysed using regression as machine learning algorithm to predict the amount of money to be dispensed by the vending machine based on day sessions and vending machine location.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This financial disaster includes the studies method of the dissertation. In more detail, in this component the writer outlines the research technique, the research method, the studies approach, the strategies of statistics collection, the selection of the pattern, the research manner, the form of statistics assessment, The chapter concludes with an outline of the ethical troubles and the studies limitations of the task, approach [41].

3.2 Qualitative Research

To fulfil the objectives of the dissertation, qualitative studies end up held. The primary feature of qualitative research is that it is maximum appropriate for small samples, at the identical time as its effects aren't measurable and quantifiable. The effectiveness of qualitative studies is heavily based at the competencies and abilities of researchers, whilst the consequences won't be perceived as reliable due to the fact they often come from the researcher's judgments and interpretations. Because it is miles more suitable for small samples, it is also risky for the outcomes of qualitative studies to be perceived as reflecting the evaluations of a far wider population [42].

3.3 Research Tools & Techniques_ In-depth interviews

For these studies, in-depth interviews were used. Depth, interviews are private and unstructured interviews, whose intention is to select out participant's emotions, emotions, and evaluations concerning a specific studies hassle. The fundamental advantage of private interviews is that they consist of private and direct contact between interviewers and interviewees, as well as do away with non-response fees, but interviewers need to have advanced the crucial skills to efficaciously convey an interview [43]. What is more, unstructured interviews provide flexibility in phrases of the go together with the drift of the interview, thereby leaving room for the generation of conclusions, which have been now not first presupposed to be derived regarding a research problem. However, there is the risk that the interview also can moreover deviate from the prespecified studies dreams and goals. As some distance as facts collection device were worried, the conduction of the research worried using a semi-mounted questionnaire, which modified into used as an interview guide for the researcher. Some sure questions had been organized, in order for the researcher to manual the interview towards the pride of research objectives, but extra questions have been made encountered at some diploma in the interviews [44].

3.4 Research Process

Meetings had been held in the direction of May and June of 2021, to benefit popularity in their participation inside the studies. More in particular, the researcher got here in contact with and asked them to take part in the research after explaining the character and the scope of the observe. In contemporary day phrases, the respondents were inclined to take part within the studies and the interviews had been completed among May and June of 2021. The discussions befell at Kabarore cell corridor in Nyabitekeri zone, Nyamasheke district, west province, and lasted about 25 to 20 mins. During the interviews have been specially kept notes, to help the researcher to examine the accumulated information. During the conduction of the interview, respondents were loose to explicit their views even in topics which have been no longer protected inside the noted areas which have been noted inside the paragraph. Finally, it needs to be stated that the conversations flowed without troubles and pleasantly.

3.5 Methodology

The smart airtime vending machine consists of three main parts. The first is IoT hardware component that build the entire circuit. This part involves sensing components, data processing component and actuators components. The second part consists of programming to make system hardware operational. The last part is data processing and analytics, which will be done using Python programming and regression as machine leaning technique and will be visualized on graph.

3.5.1 System Block Diagram

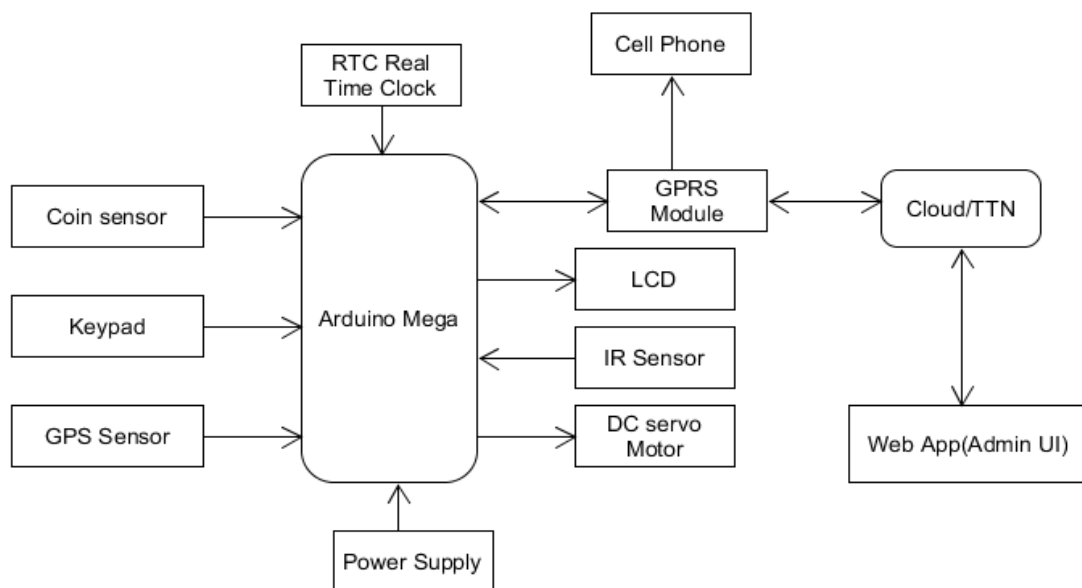


Figure 5: System block diagram

3.5.2 System Block Diagram Description

Technically the system design combines several technologies where different modules were connected to achieve the research goals. The Arduino ATmega 328 which has 32 KB ISP flash memory, 8 bits processor in 28 pin DIP package, 14 digital input and output pin and 6 analog inputs, 5 volts as power supply, 2 KB of SRAM is used as control unit[45]. The multi-coin selector CH-923/924/925/926/928 which assist six extraordinary cash is used to just accept or reject coins based on those are programmed too[46], The Motion Detection – IR Proximity Sensor that is used to stumble on the vending gadget's clients[47], SIM800 GSM/GPRS module used as communication module to link the vending machine with the cloud remote server[48], The NEO-6MV2 GPS Module used to locate the vending machine [49], The DC Servo motor used to return the coins in case the transaction is cancelled[50], 1.3 Inch LCD white colour 28×64 dot matrix display module with SPI Interface used as vending machine display,

The 4 x four matrix keypad typically is used as input [51] and an actual-time clock (RTC) as a clock that keeps song of the modern-day time and that may be used so one can program movements at a certain time. The device can pinnacle up airtime based on coins inserted into the merchandising machine and ship notification SMS to the consumer's cellular wide variety. The customers can engage with the device thru the web and keep its information to the cloud at the server-aspect.

3.5.3 System Algorithm

The system has the aims to develop an IoT system called Smart Airtime Vending Machine that helps rural citizens to buy airtime using coin where they have to enter the mobile number using the keypad, then inset coin in a vending machine, and automatically the machine dispenses the airtime equivalent to the amount inserted and also to analyse machine transaction data by building a model to predict the amount dispensed using recorded data. This analysis is done using Python programming and regression as a machine learning technique.

To achieve the system target, the system needs to perform several tasks such as detecting the location of the vending machine and display the machine location to the LCD, detecting the customer and the machine turns into active mode, showing a welcome message

and prompting the customer to enter mobile number, showing invalid mobile number message and prompting the customer to continue or to cancel the transaction, showing message prompting the customer to insert a coin, detecting coin, accepting or rejecting coin,

showing total amount inserted and prompting the customer to accept or cancel the transaction, loading airtime and providing airtime loading notification message to customer mobile number.

To realize the purpose of the system, the different main modules are connected to the Arduino mega as a microcontroller and use GPRS/GSM module to send all data to the server, Coin sensor is used to detect the correct coin based on which it is programmed, GPS module for tracking the vending machine location, IR sensor for detecting the customer, servo motor for returning rejected coin, LCD for information display, Keypad used as an input device of vending machine, RTC module as time and date remembering systems. The system has also a battery as a power supply system, a Cell phone as a customer or end-user device, a cloud server that contains a storage system and analytics algorithm, and the web interface as UI.

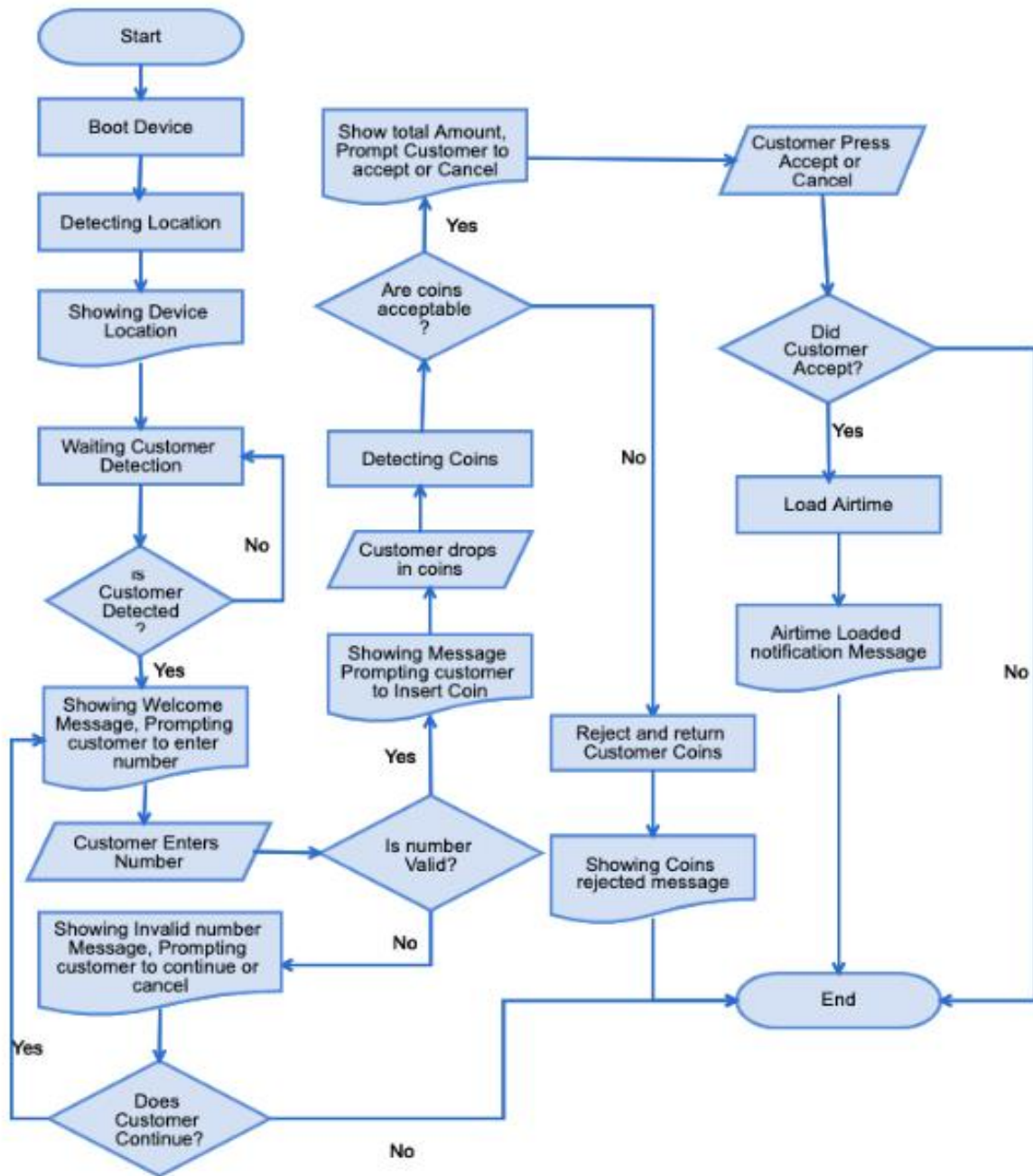


Figure 6: Flowchart

3.5.4 Machine Learning Algorithms

Machine learning is a branch of synthetic intelligence that allows computer structures to study directly from examples, information, and reveal in. Basing on nature of the records generated with the aid of the IoT gadget, linear regression as machine studying algorithm is implemented [52].

Linear Regression is a device learning set of rules primarily based on supervised studying; it is one of the maximum commonplace fashions of machine studying that performs a regression challenge. It differs from other models because it estimates a numerical value. It accommodates a predictor variable and a based variable associated with each other in a linear style. This method is used while the variables are associated linearly. As its purpose in this research is the prediction of quantity to be distributed with the aid of the merchandising system, linear regression may be used to fit a predictive version to a discovered facts set of values of the reaction and explanatory variables [53].

The prediction of the amount of money to be disbursed by means of the merchandising gadget is based on session of the day (morning, after midday and night hours) and region where the merchandising machine is positioned. This method makes use of the dataset generated with the aid of IoT machine and which is stored to a far-flung cloud server. The effects should be visualized to the dashboard and are get entry to via a web interface.

3.5.5 Description of Multi-Coin Acceptor

CH-923/924/925/926/928 is a multi-coin selector, can accept up to six types of exquisite cash at the identical time. This kind of coin acceptor is extensively utilized in vending machines, Arcade video games, Message chairs, and one-of-a-kind self-control systems. It is specially based totally on material, weight, and duration to find out coins.

Therefore, CH-923/924/925/926/928 may be very solid and correct even supposing the surroundings modifications along with temperature, and humidity, and many others. In order to increase the accuracy, we endorse specific versions of cash use great channels to installation [54].

Therefore, CH-923/924/925/926/928 could be very strong and correct even if the environment modifications together with temperature, and humidity, etc. In order to growth the accuracy, we recommend special variations of coins use one-of-a-kind channels to installation. In this research, a search kind of coin acceptor is used to accept or reject coins based on which are programmed too. It accepts the coin when the coin's material, weight, and

size meet the one is programmed for and it rejects the coin when some of these parameters do not meet with one of the coins trained to be used by the vending machine.



Figure 7: Multi-Coin Acceptor source [54]

This type combines a sorting mechanism and a change delivery mechanism. When a coin hits, the coin acceptor compares the characteristics of the coin with data from flash memory and decides on the return or acceptance of the coin. In the latter case, the coin at face value gets into the tube. The most common coin acceptors with four or five tubes. When filling the tube, the coins will be dumped into the total capacity. If it is necessary to issue a change, the computer sends a signal to the coin acceptor to issue a certain amount. The coin acceptor calculates the optimal values \u200b\u200b for dispensing, and the dispenser installed under the tubes throws the calculated number of coins into the return channel, from where the coin falls into the basket, the execution of which depends on the design of the machine in which the coin acceptor is used. Coins that fail the test go there[54].

CHAPTER FOUR: SYSTEM DESIGN AND ARCHITECTURE

4.1 Introduction

This chapter offers with the structures design and architecture where the systems layout suggests the process of defining factors of a device like modules, structure, components and their interfaces and records for a device primarily based on the specified requirements while the device structure consists of system components and the sub-structures advanced, in an effort to paintings collectively to put into effect the general system.

4.2 System Architecture

Architecture of a system is a high-level description of the whole gadget that explains the specified architecture factors and their services as well as the principles that the factors shall preserve at the same time as speaking and operating collectively.

IoT is well rooted to embedded systems as well as several technologies like pervasive systems and sensor networks. IoT is a system where the “things” used as individual or as a group are connected to one another via a network (over Internet protocol) to collaborate and perform some tasks while interacting with the digital and physical world. To design the SAVM the IoT architecture model was adopted.

4.2.1 Hardware Architecture

Development of a complete IoT system and service includes several components. Key aspect of the IoT Architecture is the data sampling [54], which can be aperiodic sampling, based on event; hence useful to relax the resource (e.g., power and bandwidth) constraints. Sampling here refers to the acquisition of data from the environment which reflect a certain state that is relevant for the system (input), e.g., temperature, motion, speed, etc.

The smart airtime vending machine can be categorized as aperiodic sampling because it reacts when the customer passes nearby the vending machine and when the coin acceptor senses and detect inserted coins.

4.2.2 Software architecture

Ultimately, software is used at business layer for management, control, security, etc., at application layer to meet the requirement by exercising the use case and at processing layer for data filtering, aggregation, etc.

Software architecture is therefore important to be considered, especially to describe the structure of the system at the upper layers.

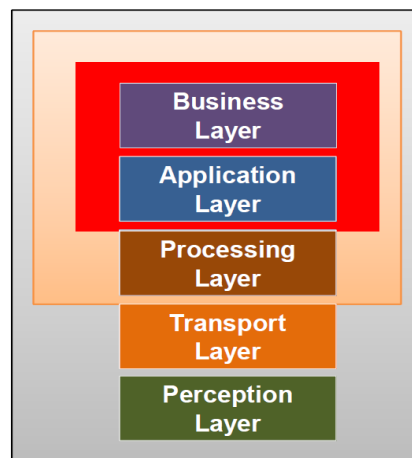


Figure 8: Upper layers responsible for Software Architecture

Software architecture mainly is based on modularity and the concept of modules may vary between programming languages:

- Module can refer to encapsulation of data and functions;
- In some case it might also refers to the collection of several functions/classes, which is also referred as package.

4.2.3 IoT system design requirements

The IoT projects requirements can be addressed if there are architectural elements delivering the respective service; and the architecture of IoT system may vary across application domain.

Though no particular consensus on the architecture, layered approach has become predominant in IoT, particular Three-layered works through different levels such as:

Perception: Collecting data from the physical world with less or no intervention of the user, hence various sensors are used.

Pre-processing: Collected data can be pre-processed before relayed over a network; this also includes data filtering.

Communication: Different entities, the “things” need to accomplish the task, need to communicate using various protocols and standards.

Application: The data collected and communicated ultimately need to be processed to meet the end user (business/individual user) needs while improving the user experience. This may include to take action with less or no intervention by the user, hence actuators can be used.

Monitoring: It is important to monitor the environment and resource (scarce resource).

4.2.3.1 The SAVM system requirements

Feature	Description
Flexibility	The merchandising device ought to be bendy to make sure reusability and composability of offerings and service additives
Compatibility	The vending machine components must compatible to ensure integration of software and hardware system components
Responsiveness	The vending machine must respond or react dynamically to provide a quick service to the customer
Security	The merchandising system must cozy the IoT users’ records from obtrusive and unintended eavesdropping.
Privacy	The vending gadget use to maintain personal information from being disclosed and shared with unauthorized parties.

Table 1: The system requirements

4.2.3.2 The SAVM user requirements

Goal	Description
Usability	The IoT based vending machine must be easy to use to facilitate customer operations
User experience	IoT based vending machine is pleasant to use
Personalization	IoT based vending machine can be personalize according to aesthetics, preferences and habits of the end-users
Unobtrusiveness	IoT based vending machine is unobtrusive
Minimum user input	IoT based vending machine requires the minimum possible inputs from the user

Table 2: The user requirements

4.2.4 Prototype circuit diagram

A circuit diagram also called a standard diagram is a simplified traditional graphical illustration of a circuit. Unlike a block diagram or format diagram, a circuit diagram shows the real twine connections being used.

A circuit diagram is a simplified illustration of the additives of a circuit using either the images of the wonderful components or trendy symbols. It suggests the relative positions of all the factors and their connections to one another.

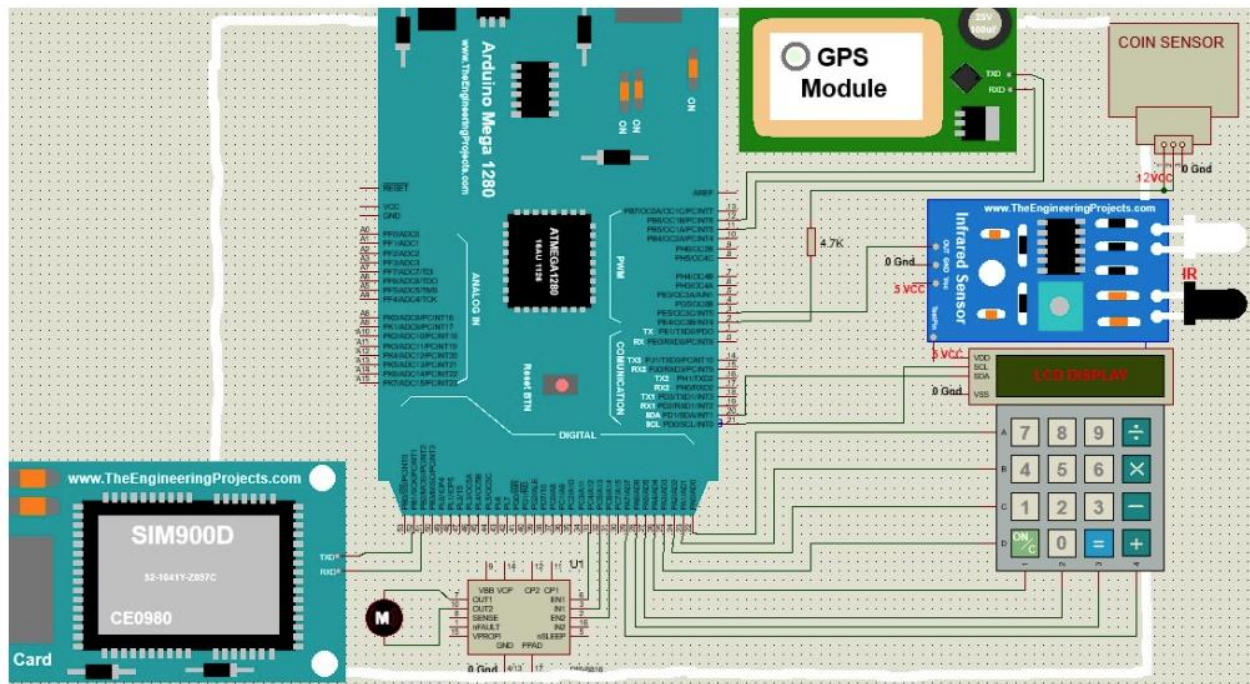


Figure 9:Prototype Circuit Diagram

4.2.5 Three-layered model

This architecture organizes the services needed to meet the requirement into three levels:

- Perception layer – Data input
- Network /Processing layer – Processing and connectivity
- Application layer – Information output as specific service

Application Layer	Responsible for delivering application specific service
Network Layer	Responsible for connectivity and processing the raw data captured from sensors in such a way it is meaningful for use
Perception Layer	Capturing information from the environment. Predominantly sensors are used to sense and gather information from the physical environment

Figure 10:Three layered model

4.2.6 Smart airtime vending machine three layered architecture

From the above perspective of IoT architecture, the Smart Airtime Vending Machine three layered architecture adopted three layered architectures as its IoT architecture with its three layers distributed as follows: The SAVM system high level architecture consists of sensors at perception layer, wireless communication at network layer and cloud services at application layer.

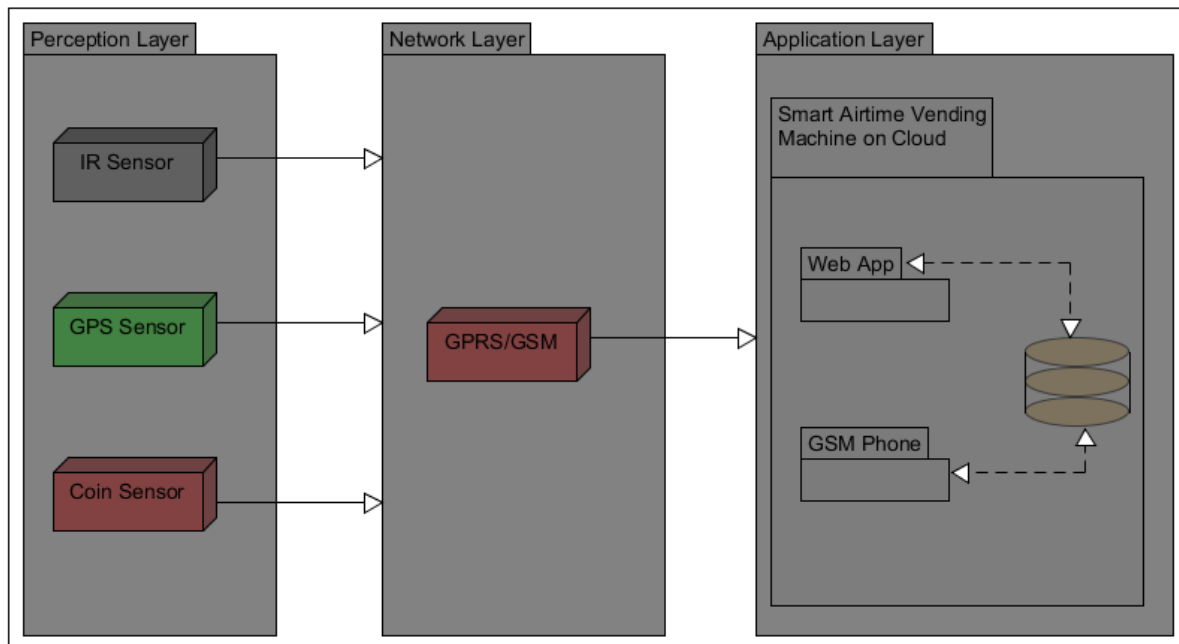


Figure 11: Three layered architecture

4.3 Smart airtime vending machine system components model

The SAVM is a hybrid system, it combines different components with different technologies, and this gives the system to be heterogeneous design system. The system design is expected to be user-friendly and does not require specific knowledge or trainings. The main SAVM feature enables automatic way of thing connection, and at the same time it provides and ensures directly or indirectly always responsive services.

The three-layered architecture of the SAVM is composed of five main components and seven sub components connected all together in three layers: VM component, Agent component, Customer component, Admin component, Cloud component.

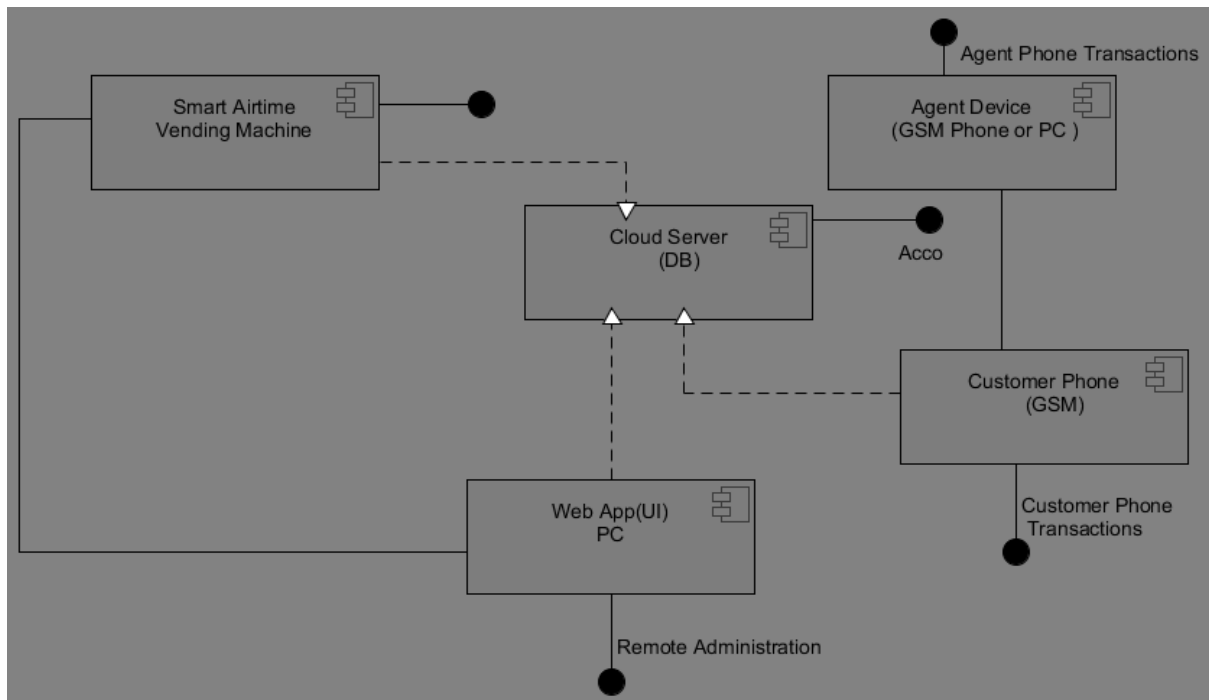


Figure 12: System Components diagram

4.3.1 Smart airtime vending machine system components model description

1. **VM Component:** Smart airtime vending machine as the main component of the system consist of different modules with different technologies which are interconnected together to perform the main goal of this research. The Arduino ATmega used as control unit. The multi-coin selector which support six different coins is used to accept or reject coins based on the ones are programmed too, the Motion detection – IR Proximity Sensor which is used to detect the vending machine’s customers, GSM/GPRS module used as communication module to link the vending machine with the cloud remote server, the GPS Module used to locate the vending machine, The DC Servo motor used to return the coins in case the transaction is cancelled, LCD used as vending machine display, the keypad used as input device and a real -time clock (RTC) as a clock that continues song of the modern-day time and that may be used with a view to program actions at a certain time.
2. **Agent Component:** Smart Phone or Person Computer: Smart phone with GSM embedded technology that serves to manage and monitor airtime transactions via web application. With this component the agent is able to view all transactions and their status (successful and failed), view agent airtime balance, vending machine status (ON or OFF) and its location. To ensure the security the system the agent can use multi factor authentication means username and password or SMS based OTP authentication.

3. **Customer Component:** GSM Phone: This component consists of a mobile phone that help the customer to receive the airtime dispensed by the vending machine. It receives also the SMS notification that shows airtime transaction information.
4. **Admin Component:** Web App and person computer or smart phone: This component consists on a web application interface which help the admin to manage and monitor the system remotely. It allows the admin:
 - To manage the vending machine (add VM, modify VM info, remove VM, view VM status and location)
 - To manage the agent (add agent, modify agent info, view agent balance and remove agent)
 - To view transactions (view all transactions and their status, Filter transactions)
 - To generate a reports
5. **Cloud Component:** Web server and Database server: Data engine of the system from cloud services such as data storage, security, privacy and execution of instruction

4.4 Smart airtime vending machine layered architecture design pattern

An architectural style, also called architectural sample, is a fixed of principles or a coarse-grained pattern that offers an abstract framework for a family of systems. Architectural style describes deployment styles, shape and layout troubles and communication factors.

In regard to the structure the SAVM is layered style architecture focus on the structural configuration of the software, such as functionalities. This implies every data request should be validated before the access to the data is permitted.

In regard to the deployment, the layered SAVM architecture resides in N-tiers situated at cloud side and communicate with sensors via internet. This categorizes SAVM architecture to service-oriented architecture (SOA) application. Services are furnished to the alternative components by way of application components, thru a verbal exchange protocol over a community. In regard to communication aspect, the SAVM architecture uses different protocols for data transmission and interlayers communication.

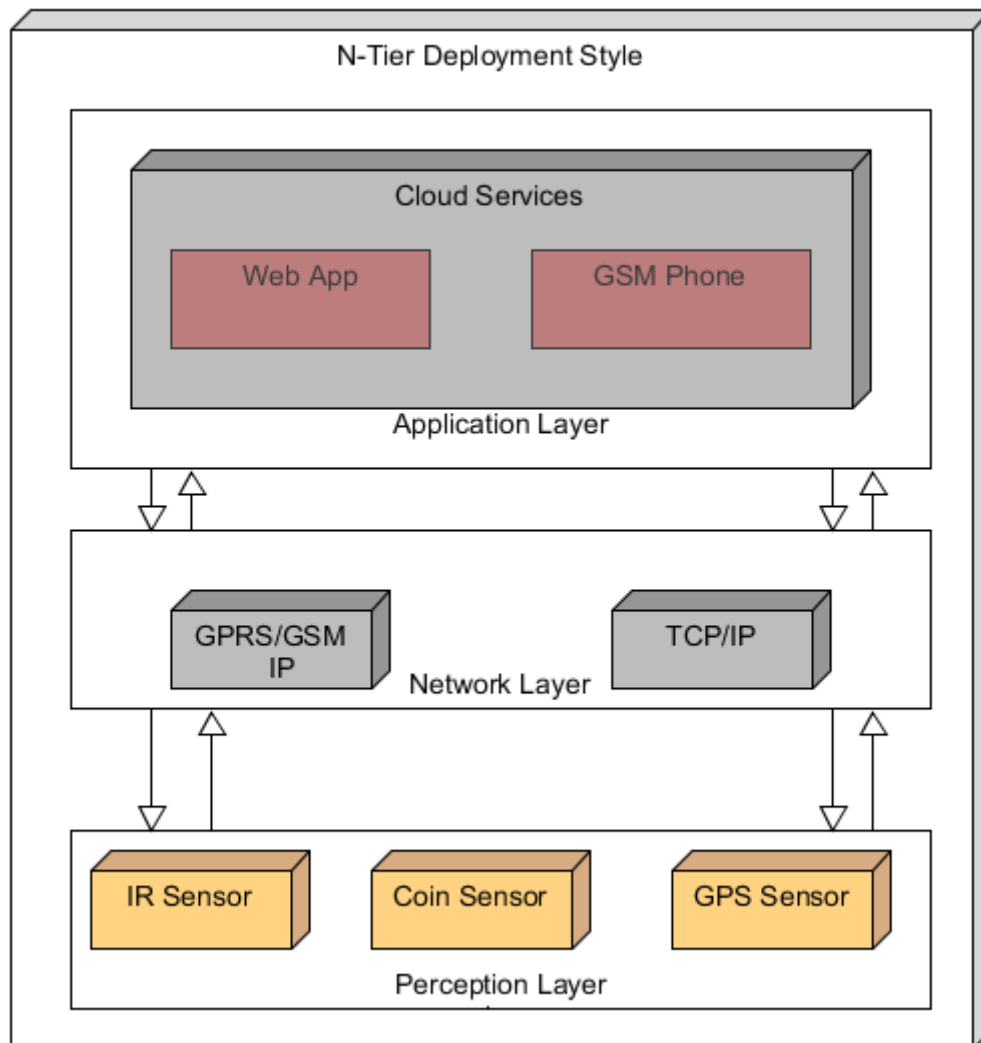


Figure 13:N-Tier Deployment style

Specifically, the above architectural style determines the vocabulary of additives and connectors that may be utilized in times of that style, together with a fixed of constraints on how they may be blended.

The components in each layer communicates with additives in other layers thru well-described interfaces.

SAVM adopted the layered structure fashion due to its blessings:

- **Abstraction:** Layers permit changes to be made on the summary level.
- **Isolation:** Allows to isolate generation improvements to person layers for you to lessen chance and minimize impact on the overall system.
- **Manageability:** Separation of middle worries enables to pick out dependencies, and organizes the code into extra achievable sections.

- Performance: Distributing the layers over more than one bodily stage can enhance scalability, fault tolerance, and performance.
- Reusability: Roles sell reusability.
- Testability: Which is accomplished as the end result of decomposability Component-Based

4.5 Smart airtime vending machine system deployment model

System deployment includes the transition of the capability to the ultimate end-person, as well as transition of aid and preservation duties to the submit-deployment guide enterprise.

In this model, The UML deployment diagram is used indicates the execution structure of a machine, including nodes such as hardware or software execution environments, and the middleware connecting them. Deployment diagrams are generally used to visualize the physical hardware and software program of a device.

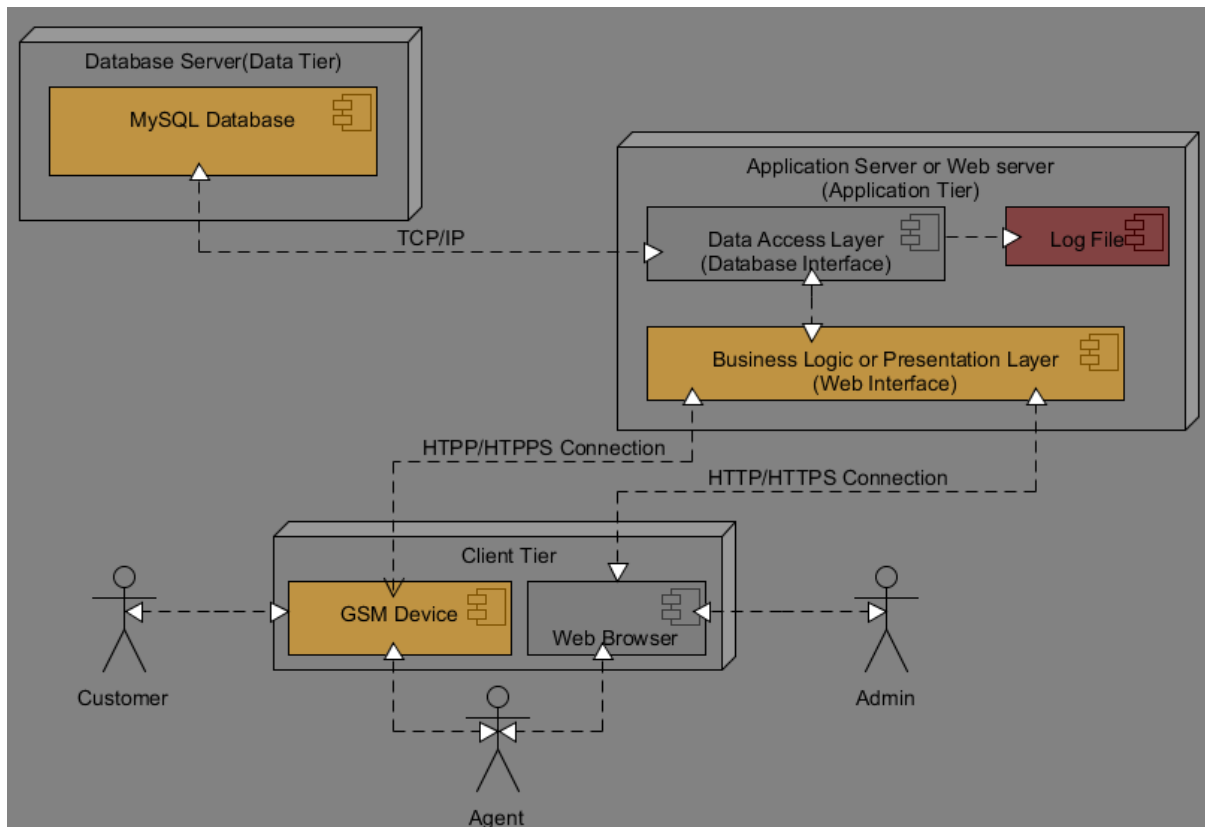


Figure 14: System deployment diagram

4.6 Smart airtime vending machine system use case diagram

The use case diagram is a way to summarize details of a device and the users within that gadget. It is normally proven as a graphic depiction of interactions among specific factors in a system. Use case diagrams will specify the events in a machine and the way the ones occasions drift, but, use case diagram does not describe how those occasions are carried out. The use cases are represented by means of either circles or ellipses.

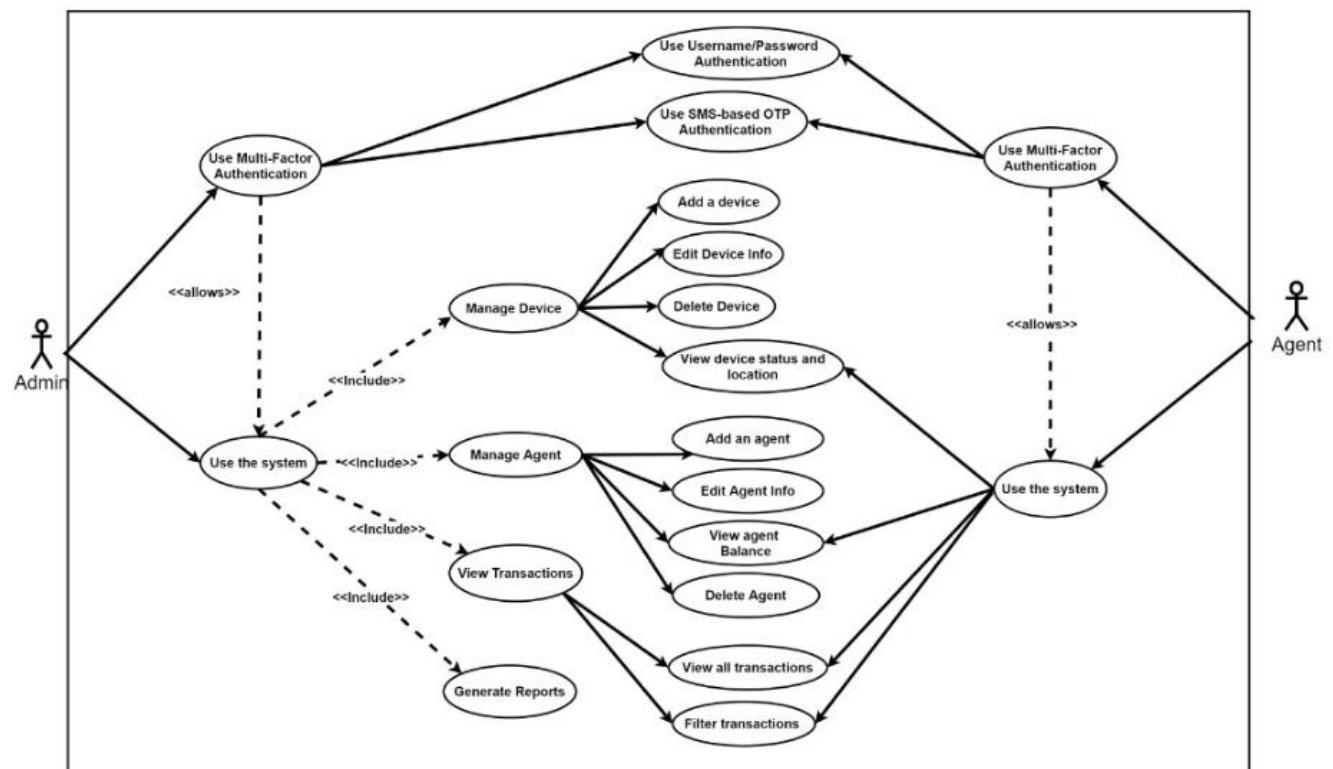


Figure 15: Use Case Diagram

From use case design, it is shown that the SAVM has five (5) main components such as: Authentication, Transactions, Users, Devices and Reports. With the above five components, definitely the SAVM met the requirements at different level and balancing trade-offs following high level concerns to be considered when thinking about software architecture.

4.7 Smart airtime vending machine software functional components

- 1. Authentication Component:** This handles user authentication and authorization in the system. It validates login username/password coupled with an SMS-based One-Time password to complete a multi-factor authentication for both system administrators and agents. This component also manage session to provide content authorization across the system for preventing authenticated users from accessing unauthorized content and to destroy active sessions to log users out.

2. **Transactions Component:** This component ensures that transactions are fetched, validated and stored efficiently. It also handles data manipulation processing required during transactions retrieval such as filtering result set by date, time, amount and location.
3. **Users Component:** System administrators and agents are primary users of the system. This component handles any account creation, update, suspension and deletion for both system administrators and agents.
4. **Devices Component:** This component ensures that any process related to devices such as adding new device, updating data of existing device, deleting a device and other sub-processes are carried out successfully.
5. **Reports Component:** The main purpose of an information system to the users is accessibility of stored information in a meaningful manner. This component handles system reports including retrieving plain data stored in a database as well as applying filtering mechanisms required to present requested data in a meaningful way.

4.8 Smart airtime vending machine database model

An Entity Relationship (ER) Diagram is a kind of flowchart that illustrates how “entities” which includes human beings, objects or principles relate to every other inside a system. This diagram also is regularly used in conjunction with facts glide diagrams (DFDs), which map out the glide of information for approaches or structures. ER diagram is crucial for modelling the statistics saved in a database. It is the fundamental design upon which a database is built. ER diagrams specify what information we can store: the entities and their attributes. They also display how entities relate to other entities.

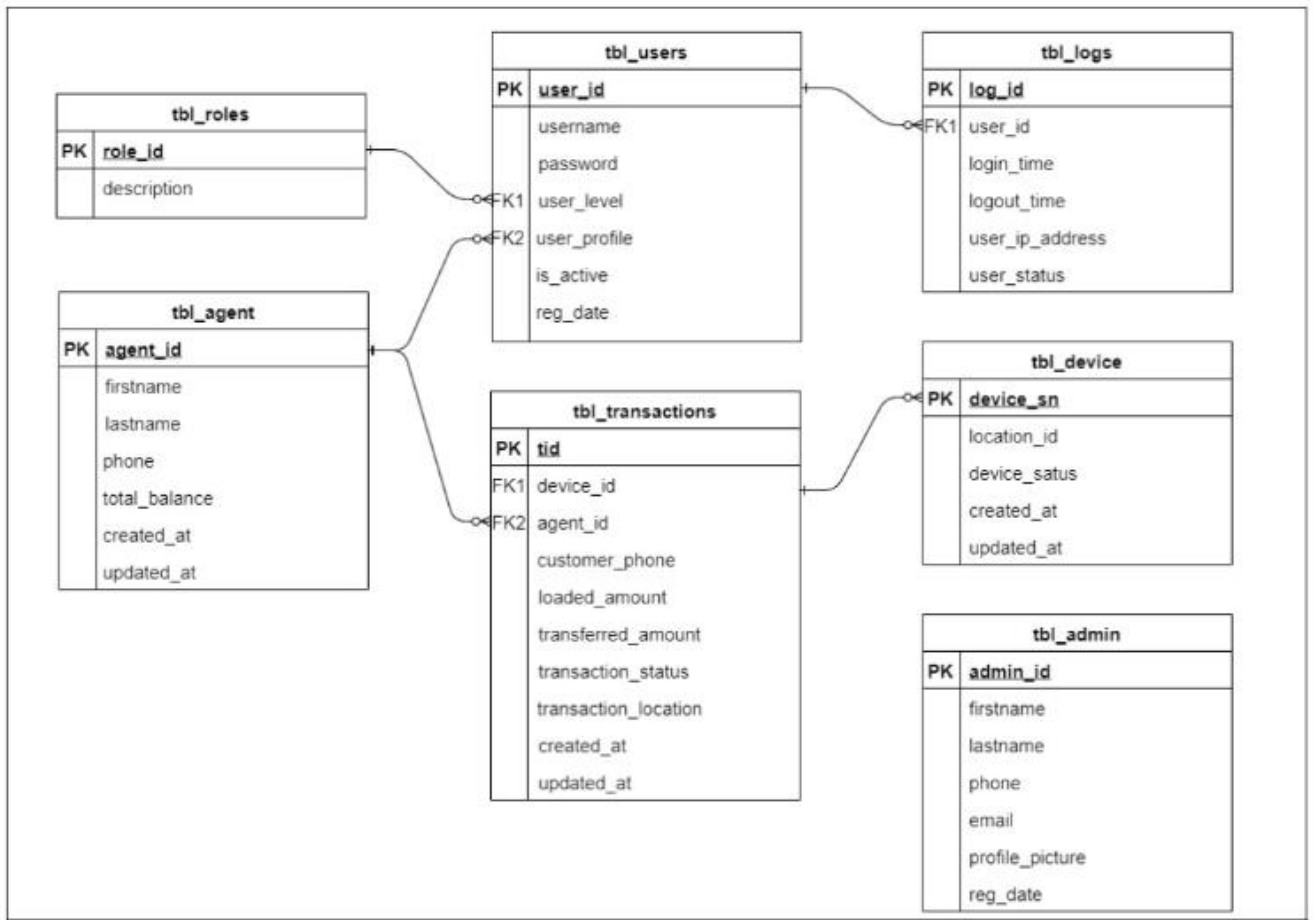


Figure 16:Entity Relationship (ER) Diagram

4.9 Smart airtime vending machine schematic diagram

A schematic diagram is a photo that represents the additives of a system, device, or different item the usage of abstract, regularly standardized symbols and lines

Schematic diagrams play a pivotal role in a variety of layout approaches, supplying a visual representation of all the components, individual tasks, and connections which are required to facilitate the operation of a device, circuit, mission, manner, or workflow.

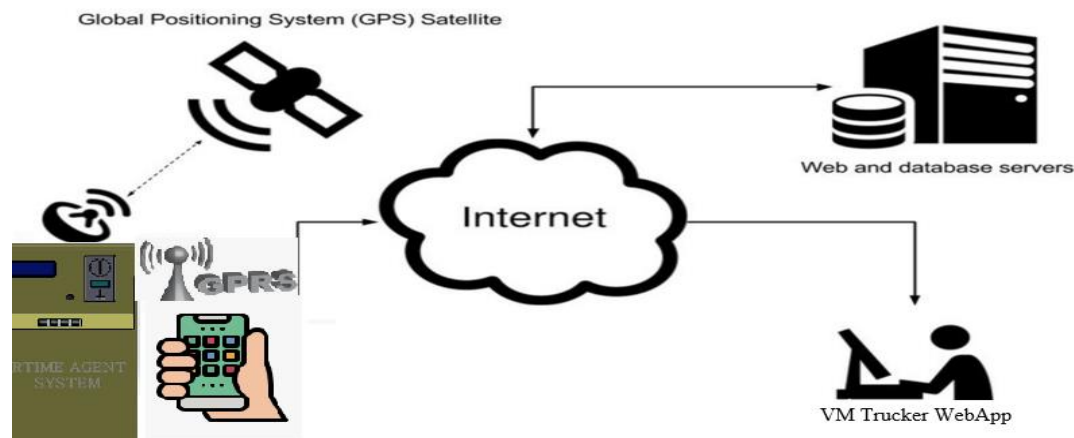


Figure 17:Schematic Diagram

4.10 Constraints of smart airtime vending machine prototype

Smart Airtime Vending Machine constraints can be discussed in the following terms:

- **Size:** The prototype cannot give the real image of the system as it cannot to cover the size of the entire system i.e., functionalities, all required prototype components are not obtained.
- **Power:** The GSM/GPRS module has a high-power consumption compare to other used components reason why requires a separate power source in order to be able to operate efficiently.
- **Cost:** Budget allocated for the prototype is not sufficient to get all required prototype components.
- **Functionality:** The prototype cannot provide all functionalities as the end product, only main functionalities to be tested with the prototype.
- **Memory:** The prototype cannot have the required memory size to store more data, e.g., SMS messages only SIM memory can be used and free cloud services memory can be used.
- **Security:** There is no way to test security aspect from the prototype itself as it cannot test all functionalities, only the security options have been implemented for web application that manages the system.

CHAPTER FIVE: RESULTS AND ANALYSIS

5.1 Introduction

This chapter describes the experimental setup of the machine, finally displaying the results of the gadget and rationalization of finding and the graphs of effects.

The prototype of the proposed gadget was built the usage of bodily devices. The gadgets used are Arduino Mega, Coin sensor, infers sensor, GPRS/GSM module, GPS, LCD, and keypad System Prototype

To build a prototype of the proposed system, the interconnection of all components was done systematically and end by a successful smart airtime vending machine.

The programs' codes were uploaded into the real Arduino mega board hardware using Arduino IDE software. Furthermore, a web-based application called Air Time Vending Machine was developed as the user interface for information visualization, the database for airtime transaction data storage, and vending machine remote monitoring

Figure21, Figure22 and Figure23 show the experimental setup of the Smart Airtime Vending Machine prototype,



Figure 18: Interconnection of vending machine components

This figure shows the interconnection of vending machine components, it also shows some of the display messages which come to the screen to guide the customer



Figure 19: Fixing of vending machine components

This figure indicates the fixing of vending machine component in housing



Figure 20:Vending machine after fixing all components

This figure indicate the vending machine after fixing all component in the housing

5.2 System Visualization

The developed web-based application called Air Time Vending Machine is used to visualize the Air Time Vending Machine information which helps the administrator and the airtime agent to get real-time information about the operations of the machine. the visualized information is represented in a number of the dashboard and by the graph, which shows the transaction amount versus the transaction time. Shown on Figure24, Figure25 and Figure26

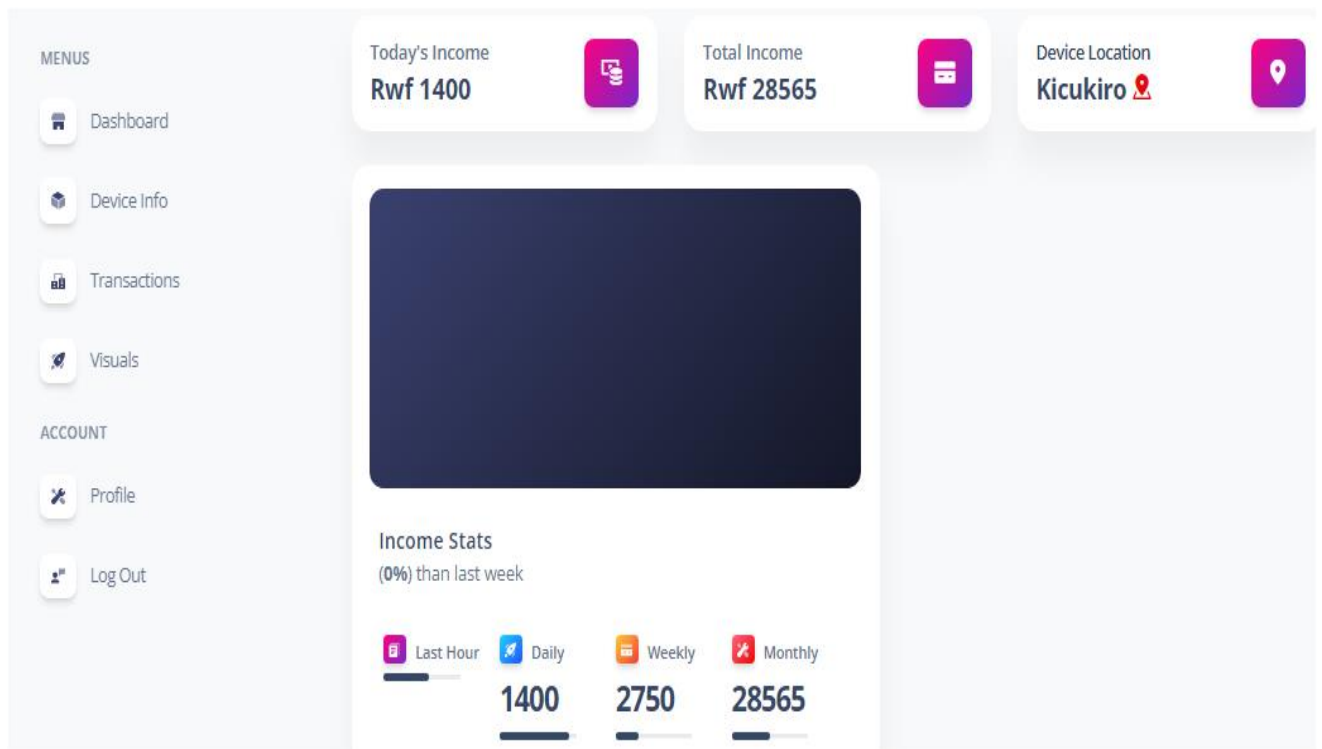


Figure 21:Admin dashboard

This figure shows admin dashboard where indicates the today's income, total income, device location, device information, transactions and some visual representations

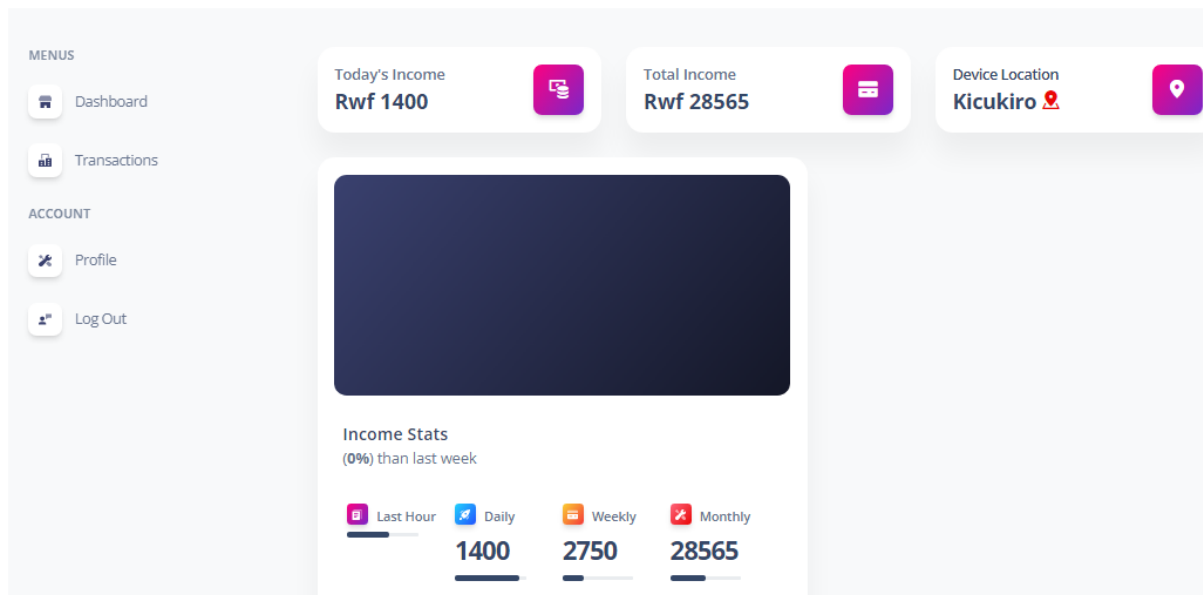


Figure 22:Agent dashboard

This figure shows admin dashboard where indicates the today’s income, total income, device location and device information

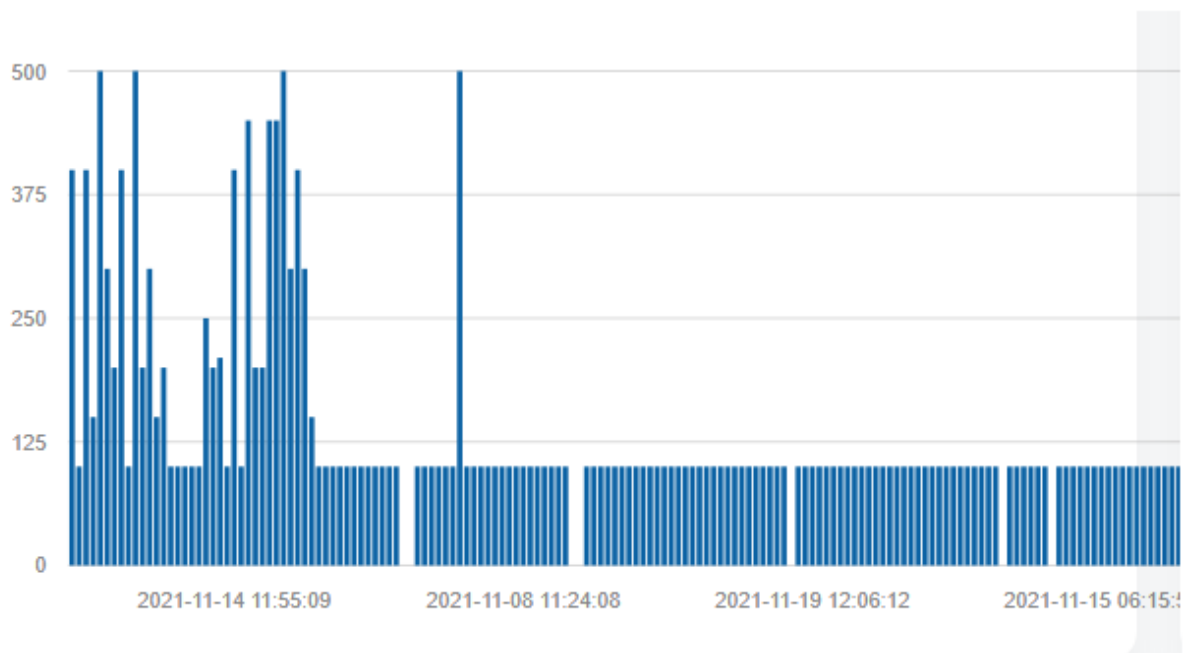


Figure 23:Transferred amount versus transaction time

This figure shows the transaction amount versus the transaction time

5.3 Analytics and Results

Analytics and results aim is to explain the findings and the graphs of the results. The analytics was done using python where three algorithms such as Linear Regression, Decision tree, and random forest were used. after the results from that analysis was the key to concluding if the goals were achieved.

5.3.1 Dataset

	Transactions_Average	Session_Day	Session_Week	Handsets	Population	Size	NEW_AMOUNT
0	Trans_Area_Date_Session_1	Afternoon	Working-Day	314	513	7819	25050
1	Trans_Area_Date_Session_2	Break-Time	Working-Day	308	682	11940	26700
2	Trans_Area_Date_Session_3	Afternoon	Week-End	212	611	7177	24550
3	Trans_Area_Date_Session_4	Morning	Working-Day	273	638	6353	25550
4	Trans_Area_Date_Session_5	Afternoon	Working-Day	308	555	10129	25700

Figure 24:Dataset

This table shows the transaction average, the average is calculated based on the different number of times the machine has been deployed on the same location but different days and sessions.

5.3.2 Scatter Plot - Amount vs Population

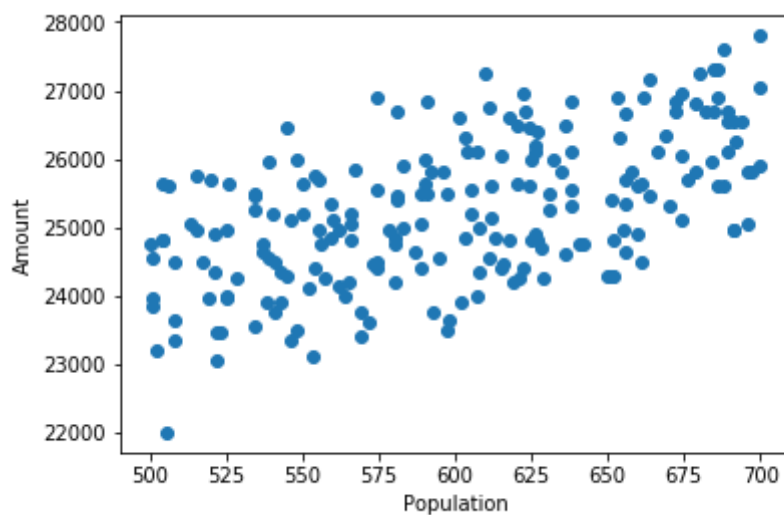


Figure 25:Amount vs Population

The scatter plot indicates the amount versus the population, the results show that the amount generated has a link with the population. As the population increases the amount also increases

5.3.3 Scatter Plot - Amount vs size cell phone handset

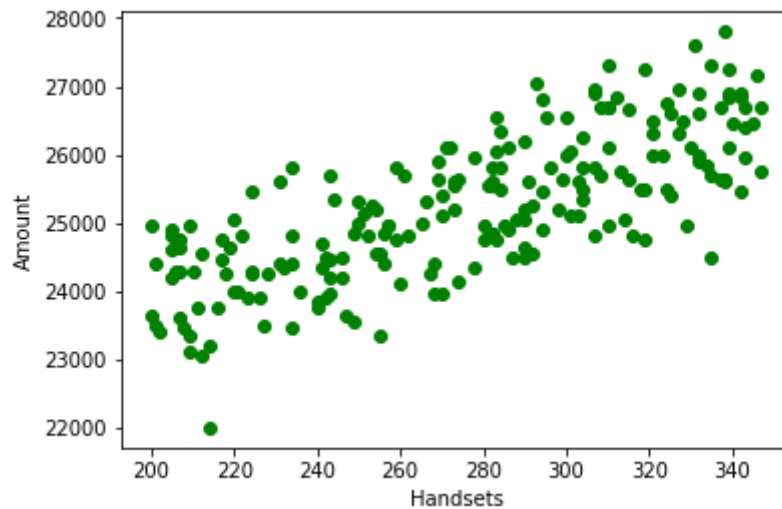


Figure 26: Amount vs size cell phone handset

The scatter plot indicates the amount versus the cell phone handsets, the results indicate that the amount generated has a link with the cell phone handsets. As the cell phone handsets increase the amount also increases

5.3.4 Transctions_Average based on sessions

	Session_Day	Session_Week	Handsets	Population	Size	NEW_AMOUNT
0	Afternoon	Working-Day	314	513	7819	25050
1	Break-Time	Working-Day	308	682	11940	26700
2	Afternoon	Week-End	212	611	7177	24550
3	Morning	Working-Day	273	638	6353	25550
4	Afternoon	Working-Day	308	555	10129	25700

Figure 27: Average based on sessions

This table indicate the amount of the machine have dispensed based on the session of the day and the week

5.3.5 Original dataset with pre-processed dataset

	Afternoon	Break-Time	Evening	Morning	Week-End	Working-Day	Session_Day	Session_Week	Handsets	Population	Size	NEW_AMOUNT
0	1	0	0	0	0	1	Afternoon	Working-Day	314	513	7819	25050
1	0	1	0	0	0	1	Break-Time	Working-Day	308	682	11940	26700
2	1	0	0	0	1	0	Afternoon	Week-End	212	611	7177	24550
3	0	0	0	1	0	1	Morning	Working-Day	273	638	6353	25550
4	1	0	0	0	0	1	Afternoon	Working-Day	308	555	10129	25700

Figure 28: Original dataset with pre-processed dataset

This table shows the original dataset with pre-processed dataset

5.3.6 Final dataset to be modeled

	Afternoon	Break-Time	Evening	Morning	Week-End	Working-Day	Handsets	Population	Size	NEW_AMOUNT
0	1	0	0	0	0	1	314	513	7819	25050
1	0	1	0	0	0	1	308	682	11940	26700
2	1	0	0	0	1	0	212	611	7177	24550
3	0	0	0	1	0	1	273	638	6353	25550
4	1	0	0	0	0	1	308	555	10129	25700

Figure 29:Final dataset to be modelled

This table shows the dataset to be modeled, with the corresponding cell phone handset and population parameters that impact the transections

5.3.7 Model 1 Results: Linear Regression

```
Columns: Index(['Afternoon', 'Break-Time', 'Evening', 'Morning', 'Week-End',
               'Working-Day', 'Handsets', 'Population', 'Size', 'NEW_AMOUNT'],
              dtype='object')
Model Coefficient: [-3.70517211e+01  6.11064178e+01  8.16795192e+01 -1.05734216e+02
                   4.44028548e+01 -4.44028548e+01  1.82097738e+01  1.04537306e+01
                   4.51021023e-03]
Model intercept: 13904.292947262536
=====Model 1 of LINEAR REGRESSION Results=====
Score of Training is: 0.8903852117143808
Score of Testing is: 0.9120021731611317
Errors in the Training is: 119682.84436695972
Errors in the Testing is: 97575.82159684028
```

Figure 30:Linear Regression Results

5.3.8 Model 2 Results: Decision Tree

```
=====Model 2 of Decision Tree Results=====
Score of Training is: 0.8155324323288857
Score of Testing is: 0.7808301474106807
Errors in the Training is: 201410.80904892852
Errors in the Testing is: 243025.07463985746
```

Figure 31:Decision Tree Results

5.3.9 Model 3 Results: Random Forest Regressor

```
=====Model 3 of Random Forest Regressor=====
Score of Training is:  0.8561406510631853
Score of Testing is:  0.8274729914291904
Errors in the Training is:  157072.7484750867
Errors in the Testing is:  191305.45848327866
```

5.3.10 Model Results: Comparison Tables

Metrics	Dataset	Linear Regression	Decision Tree	Random Forest Regressor
SCORE	Training	89%	81%	85%
	Testing	91%	78%	82%
MSE	Training	119682	201410	157072
	Testing	97575	243025	191305

Table 3:Results comparison tables

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

This chapter summarizes all the contributions of this study, and sooner or later, some suggestions for destiny paintings were mentioned

6.1 Conclusion

This project explores the use of the Internet of things in vending machine. The project's works include requirement analysis, literature review, system design, and experimental work of the IoT-based prototype to dispense airtime using coin sensor and GPRS/GSM technology for communication and GPS technology for monitoring and tracking and cloud Server, and database for data processing and storage.

The proposed prototype will improve the airtime vending system's efficiency and sustainable management of airtime agent. It will facilitate safe selling and buying of airtime across the country especially in rural area where to get airtime seems to be a problem. The Internet is also used for linking cloud platform and application users.

The objectives of this research were covered as entire and the results found in different models indicate that the vending machine can provide positive impact in society.

6.2 Recommendations

This research aim was to develop an IoT based Smart Airtime Vending Machine that helps rural citizens to buy airtime using coins where they have to enter the mobile number using a keypad then inset coin in the vending machine, and automatically the machine dispenses the airtime equivalent to the amount inserted and also to analyse machine transaction data using Python programming and regression as a machine learning technique.

However, the developed machine changed into for finishing touch of the writer's Master's degree studies. Thus, there are a few barriers from this studies assignment that wishes to be addressed in future research. This proposed prototype must be verified inside the special rural are of the county to be stepped forward. The system should also be added more functionalities like using currency note as to buy airtime, mobile money option where citizen can deposit and withdraw money without facing the current mobile money agents.to get best accuracy it will be good for research to using multiple vending machines on different location and take long time for building a good sample dataset.

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