



Design and Development of an Online Purchase System for Residents of a University Community

Angela Makolo
University of Ibadan
Department of Computer Science
Oyo State, Nigeria

Ayinmode Goodness
University of Ibadan
Department of Computer Science
Oyo State, Nigeria

ABSTRACT

Electricity is now an essential source of energy for humans and is purchased like any other goods and services. As a result, electric utilities have developed a variety of invoicing and metering methods. Nigeria has mostly transitioned to a prepaid metering scheme for electricity consumers. However, in many communities in the country like estates and universities, consumers are provided with only a manual mode of payment that is inconvenient, laborious, and available only on working days. In response to this obstacles, this work has developed an online electricity unit purchase system that will help residents of such communities purchase electricity units online. This will improve the overall consumer experience and surmount the limitations of the manual mode of payment. The implementation result of this work is a mobile application that enabled consumers to make payments online using a payment gateway and obtain a receipt containing the coded energy units purchased through the application.

General Terms

Web, Software Engineering

Keywords

Electric Utilities, Prepaid Metering, Payment Gateway, Energy Units

1. INTRODUCTION

Electrical energy is one of the most important forms of energy to the daily operations of humans. Commercial scaled electricity that will be used by different types of consumers is generated at industrial facilities called power Stations. The electricity generated is transmitted at high voltage directly to distribution substations where the high voltage is regulated for different commercial purposes. Distribution stations transmit electricity directly to consumers through a complex electrical distribution system made of transformers and overhead power lines or underground cables

Distribution stations may be owned by an electric utility. An electric utility is a company in the electric power industry (often a public utility) that engages in electricity generation and distribution of electricity for sale generally in a regulated market [1]. Nigeria has 28 power generating plants that transform hydro and gas power into electrical power connected to its national electricity grid with installed generating capacities ranging from installed capacity ranging from 22 MW to 1074 MW and 11 licensed Electricity Distribution Companies (DISCOs) [2] that transmit electricity to the end users over different regions on the national grid and between them are governmental bodies responsible for overseeing the transmission of electricity from the GENCOs

to the consumers. The flow of revenue generated in the electricity market to all market participants starts from the DISCOs who receive payments from consumers for the electricity provided.

There are 2 categories of energy consumers that Nigerian DISCOs bill based on the amount of energy consumed, they are the: post-paid consumers and the prepaid consumers who are the newest from of energy users in the country. The only difference between these categories of consumers is the type of energy meters used for recording the amount of electricity consumed which is measured (in kilowatt-hours kWh), and the mode of payment by which these consumers pay for electricity supplied.

Post-Paid energy consumers are billed on a scheduled basis (i.e. quarterly, monthly), the electromechanical meter records the amount of electricity used and an official from the DISCO would come over to the premises to make readings with which DISCO would give an estimated bill and then the consumer would pay to avoid disconnection. The entire process from meter reading by an official down to the consumer's payment has not always been favourable. Apart from the security issues that are raised by having a stranger come into a premises, commonly consumers are billed arbitrarily by corrupt officials and will also incur additional charges on electricity they did not consume because of estimated billing. Also the entire payment process could be stressful as consumers would be required to go the nearest vending office of the DISCO supplying them to make payments to avoid disconnection or be reconnected back to the grid.

The Pre-paid metering system was introduced to eliminate the problems of the Post-paid metering system. This system involves consumers possessing credit in their electricity account with the DISCOs before using the electricity service provided [3]. This billing system utilizes electronic meters or smart meters called prepaid meters in the context of the prepaid services provided. The prepaid electricity billing system is an effective concept in which the consumer can recharge their balance in their electronic meters like mobile phone recharges [4]. Currently, in Nigeria prepaid meters are recharged with energy units purchased at DISCO vending stations. Units purchased are issued as codes on a paper slip. The code will be entered by the customer to recharge the prepaid meter [5].

The new system provided consumers with the much needed control on the way they related with electricity supplied from the DISCOs. Consumers make a pre-payment up-front through vendors to purchase electricity units to be able to gain access to electricity supplied by their DISCO. When the units are depleted, the electricity supply is promptly disconnected from the meter. The prepaid billing system surmounts the

limitations and challenges of the post-paid system, it comes with advantages such as enabling consumers to have knowledge and control of energy consumption, reducing the level of interaction between DISCOs officials and customers as there's no need for officials to physically disconnect customers from the electricity grid. There is an immediate restoration of electricity to the prepaid customers upon the purchase of energy units (credit token) in contrast to the experience with customers with post-paid, days and weeks may elapse before help comes to them for reconnection when the need arises [3].

Payments for credit tokens take place physically with a vendor involved and after making a payment consumers would be given a credit token which would be entered into the meter and electricity is supplied.

In recent years, due to difficulties involved in having to go to a vendor or even a bank to make payments, DISCOs have introduced a new method of payment whereby customers can make a purchase and also get a generated unique credit token through online means. This online payment platform is not available to all electricity consumers, for instance there are certain establishments like universities and other forms of communities that have residential housing units that consume electricity within them, but these housing units do not have access to pay directly to DISCOs through an online platform because they are supplied electricity directly by such establishments. These establishments provide each resident with a private prepaid meter, and each resident is expected to go physically to the delegated vendor of the establishment to make a purchase to get a credit token which would be fed in to the prepaid meter. This process could be laborious and sometimes residents have to even go through banks to be able to make payments into a designated account before being able to make a purchase at the vendor's location. Besides from having to deal with queues, residents are also not able to make payments after office hours of the bank or vendor, public holidays and weekends (i.e. Saturday, Sunday), and therefore may be in darkness until the bank or vendor is available if their number of available electricity units has been exhausted.

2. RELATED WORKS

Several research work and efforts both in Nigeria and other parts of the world, have gone into improving the prepaid billing system, some of which are discussed below:

[6] focused on the design and development of a web-based electricity prepaid system for a university community to eliminate unnecessary procedures required to purchase electricity units for prepaid meters. For implementation, they used simulated prepaid meters, and utilized Luhn's algorithm for generating energy units that would be decoded into electricity units by the meters. However the system was web-based and did not feature the integration of a payment gateway or method for added convenience of customers.

[7] in their paper, they proposed a method of using telecommunication systems to automate data transmission from the server to the customer via SMS and email.

[8] designed and modelled an Intelligent Prepaid Energy Meter and simulated using matlab/simulink tools.

3. METHODOLOGY

3.1 System Modelling

System modelling is the process of constructing abstract

models of a system, each of which presents a different view or perspective of that system to develop. Modelling the system helps the analyst in describing and understanding the new system's functionalities. Models of the new system are used during requirements engineering to help explain the proposed requirements to other system stakeholders. This paper employs modelling notations from the Unified Modelling Language (UML), a standardized modelling language that comprises an integrated set of diagrams designed to assist system and software developers in specifying, visualizing requirements.

3.1.1 Overview of System

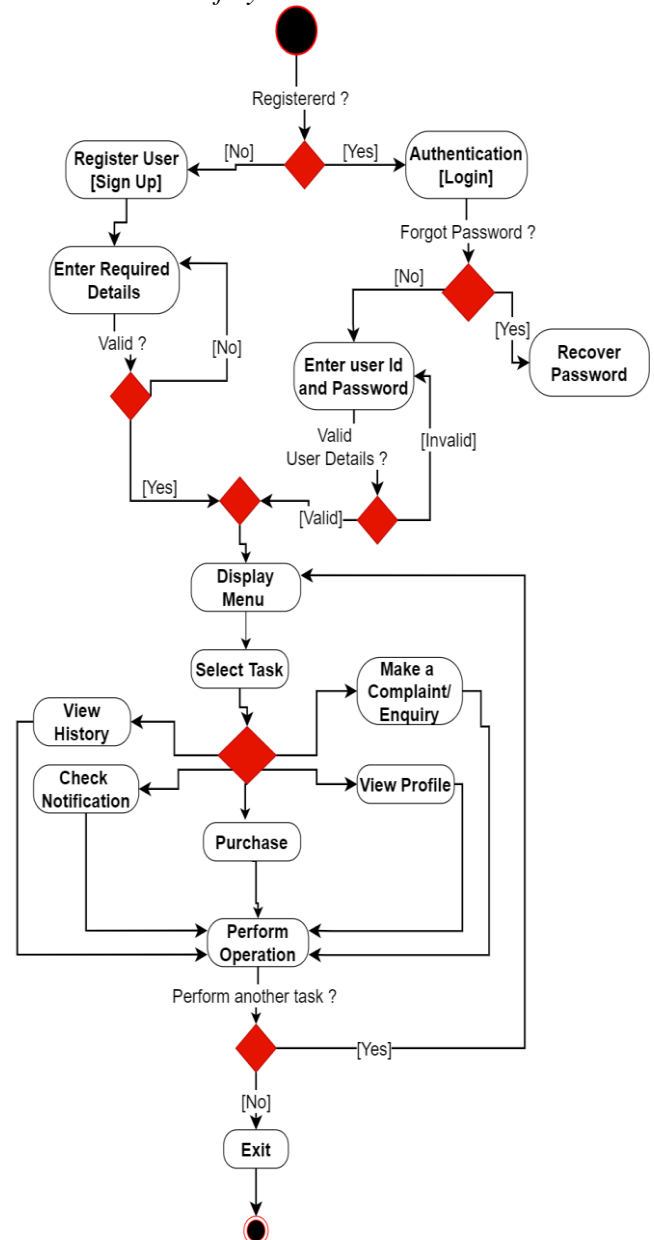


Figure 1: Overview of System

The system is composed of the following modules:

3.1.1.1 Login

The user is introduced to the software environment through the welcome page. On this page, the user has the option of either 'logging in' as an existing user or creating a new account as a new user. To login into the system, the

application requires the user to enter their username and password. Logging in takes the user to the dashboard page which displays a menu of the systems functionalities.

3.1.1.2 Registration

To register users will enter in some details along with their meter number, all of which would be saved in a database and used by the system’s processes. After registering the user will login with their email and password to access the system’s functionalities.

3.1.1.3 Purchase

This module takes in the monetary amount a user wishes to spend on electricity units as input. While the user is entering in this amount the module simultaneously generates the number of electricity credit units the specified amount can buy. To make the payment the user tapson the pay button. This gesture calls on Paystack payment gateway API and a dialog pops up allowing the user to interact with the API through entering their card details, phone number, and the one-time password (OTP) sent to their phone number. When the customer authorizes the transaction, Paystack will debit the customers bank account and display the status of the transaction. On a successful transaction, an alert dialog will pop up to show the user that the transaction was successful and will display the credit token purchased.

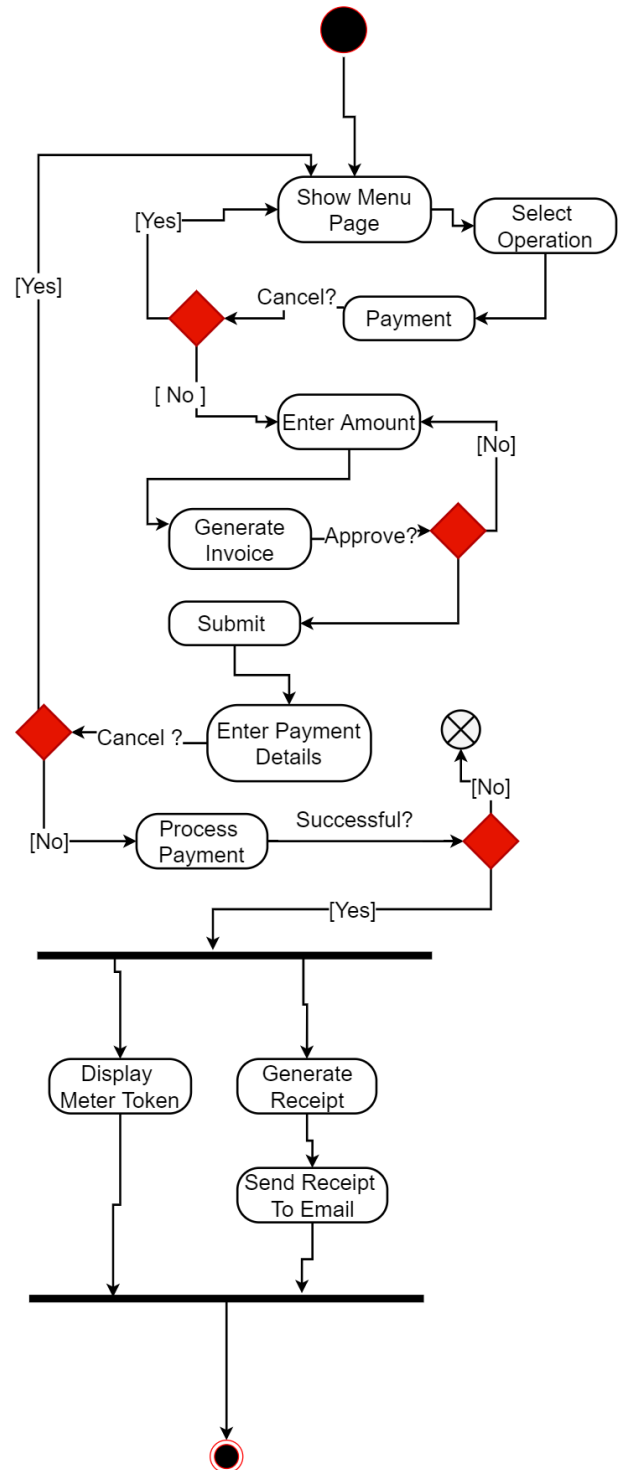


Figure 2: Purchase Activity Diagram

3.1.1.4 Receipt Generation

Important details of every successful transaction is saved in the database. Therefore users can view a history of all the details of their previous transactions. Users can download a receipt of any transaction as a pdf file.

3.1.1.5 Complaints

Important details of every successful transaction is saved in the database. Therefore users can view a history of all the details of their previous transactions. Users can download a

receipt of any transaction as a pdf file.

services.

3.1.1.6 General Announcements

Customers will be notified of important information about

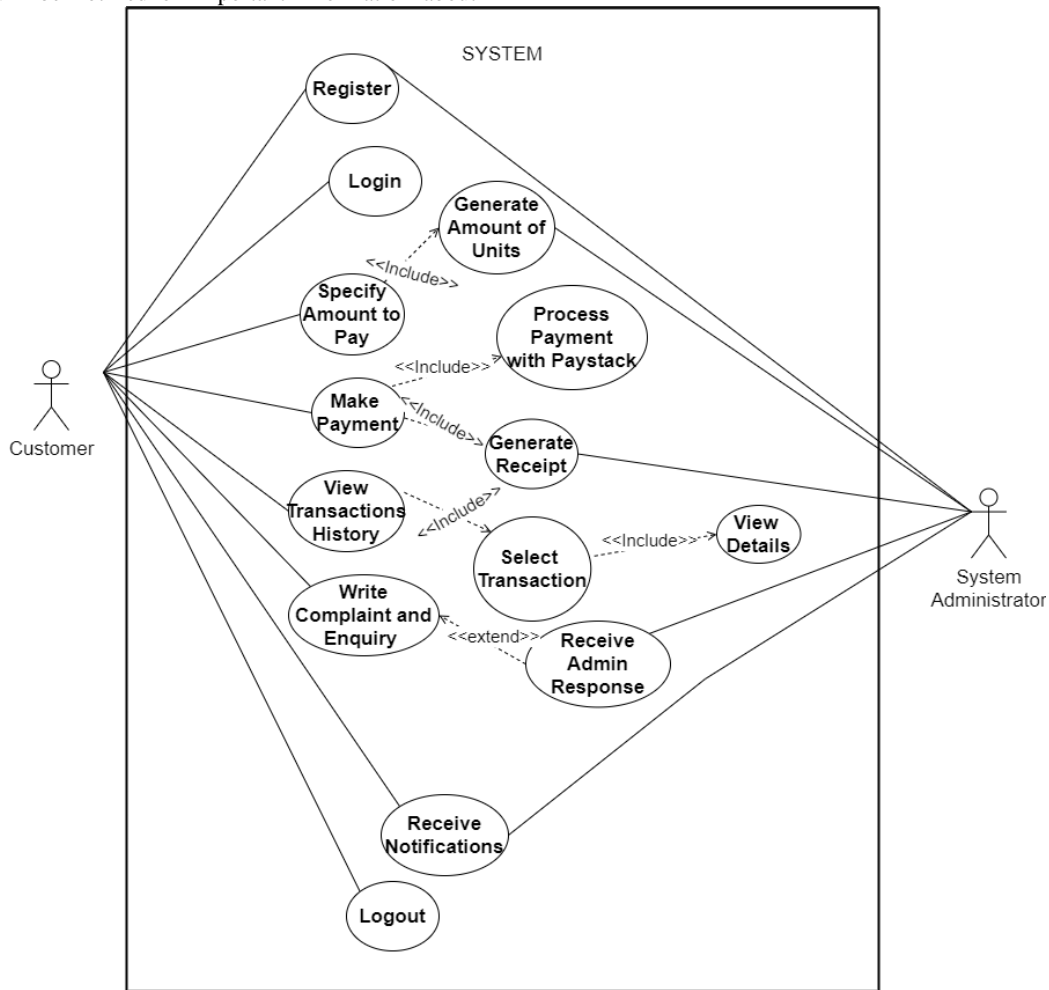


Figure 3: Use Case Model of the Application

3.1.2 Entity Relationship Diagram

ER Diagram stands for Entity Relationship Diagram, also known as ERD is a diagram that displays the relationship of entity sets stored in a database. In other words, ER diagrams help to explain the logical structure of databases. ER diagrams are created based on three basic concepts: entities, attributes and relationships. For this work, the database was developed

with MySQL.MySQL is an open source relational database management system (RDBMS) with a client-server model. RDBMS is a software or service used to create and manage databases based on a relational model. It makes use of Structured Query Language, which is a programming language that helps you manage and access data in a relational database.

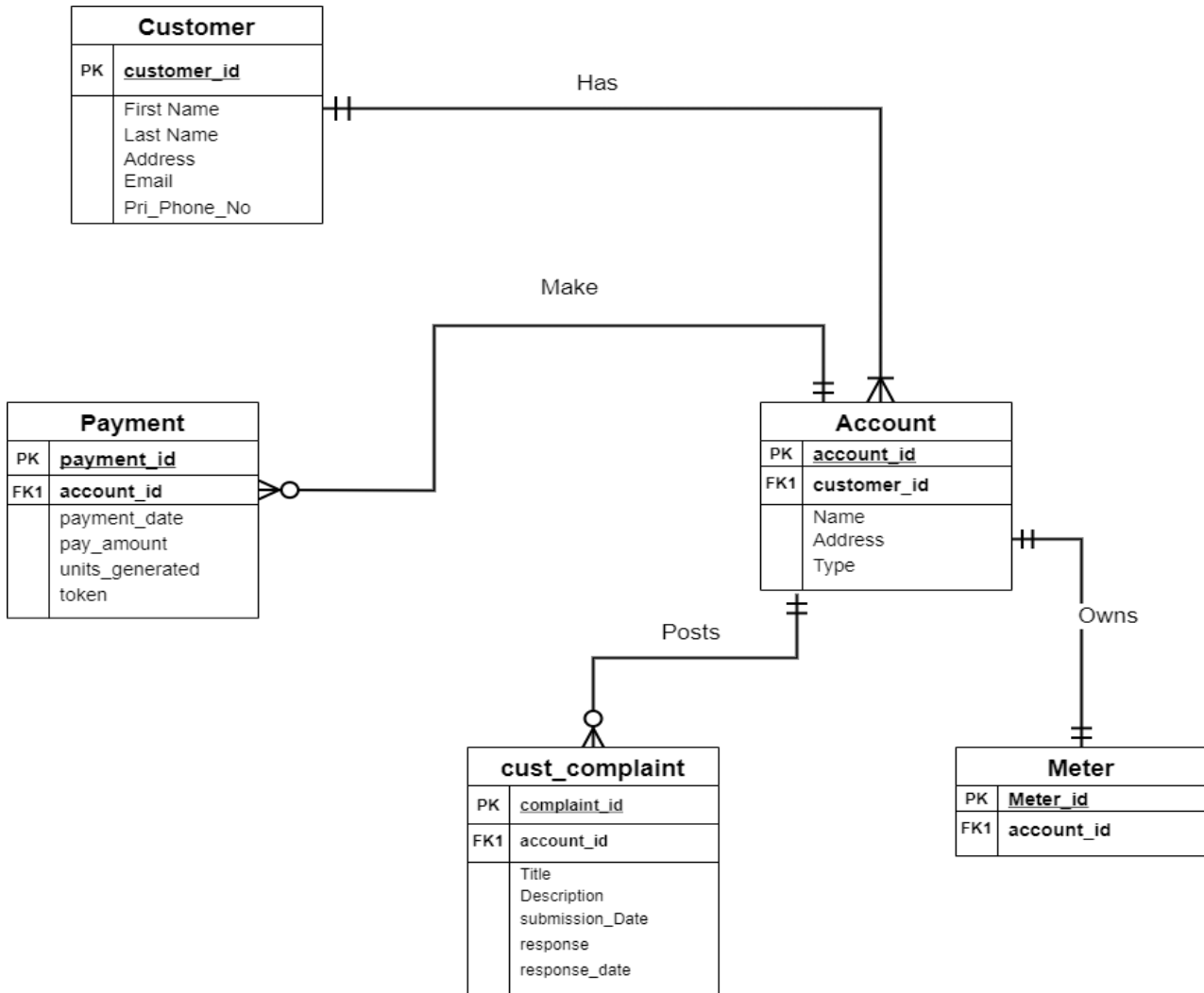


Figure 4: Entity Relationship Diagram

4. IMPLEMENTATION

The application was developed with the Flutter SDK: an open source UI software development kit for building natively compiled applications for mobile, web, desktop, and embedded devices from a single codebase. This implies that one programming language and one codebase can be used to develop a single app that will run on different mobile operating systems (e.g., iOS, Android)[9]. Flutter uses the dart programming language to develop mobile applications.

A server-side open-source PHP framework named Laravel was used for the development of the application program interfaces (APIs). Laravel provides powerful database tools including an ORM (Object Relational Mapper) called Eloquent for simpler data access and manipulation, and built-in mechanisms for creating database migrations and seeders [10].

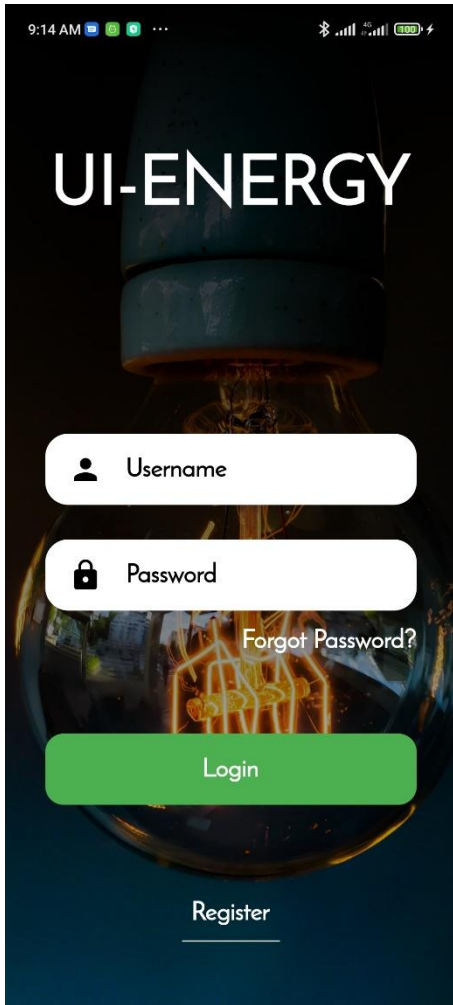


Figure 5: Login Page

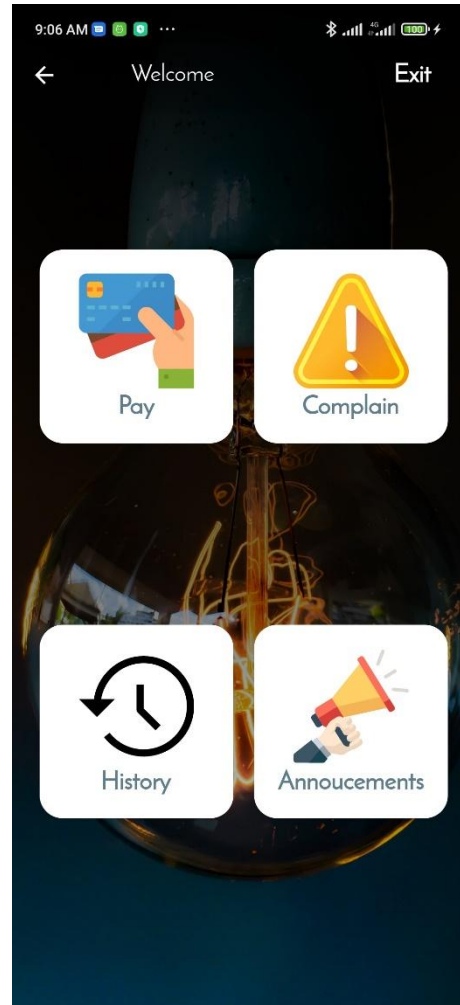


Figure 6: Dashboard Page

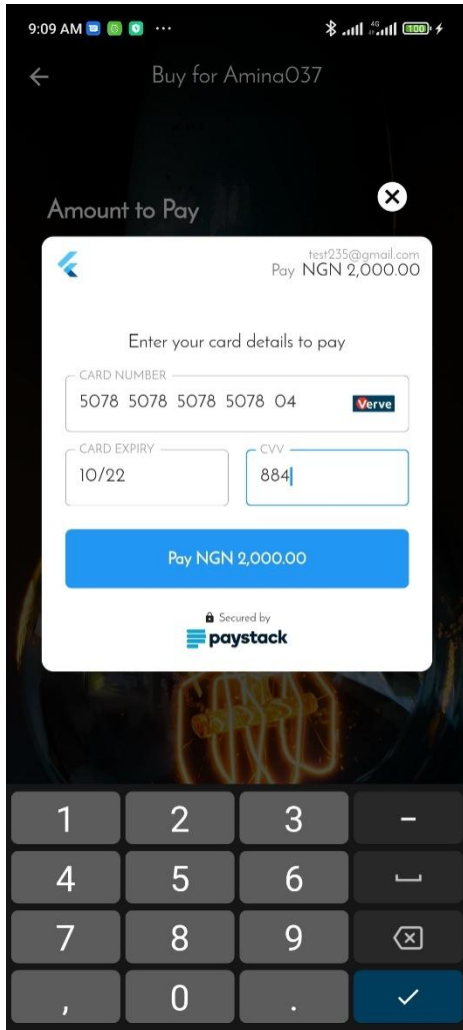


Figure 7: Card Details Page

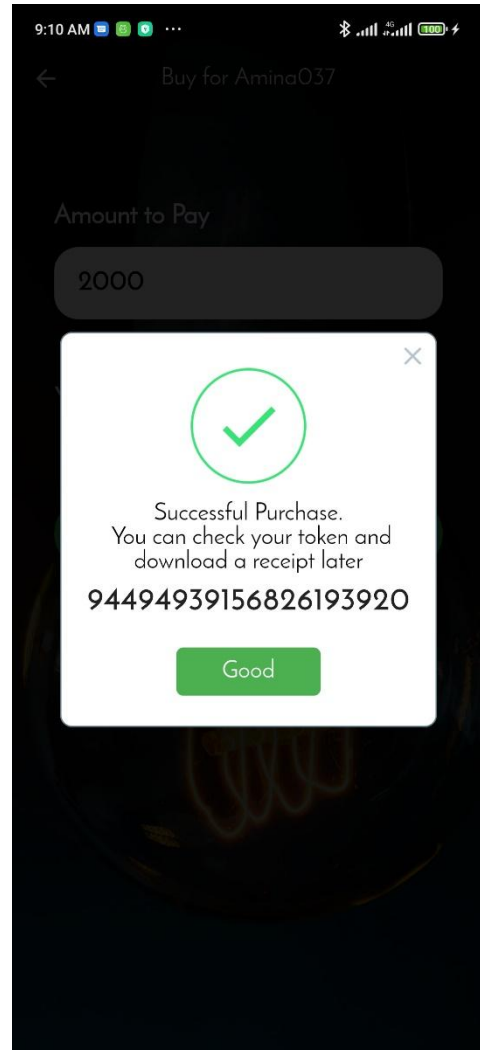


Figure 8: Credit Token Dialog

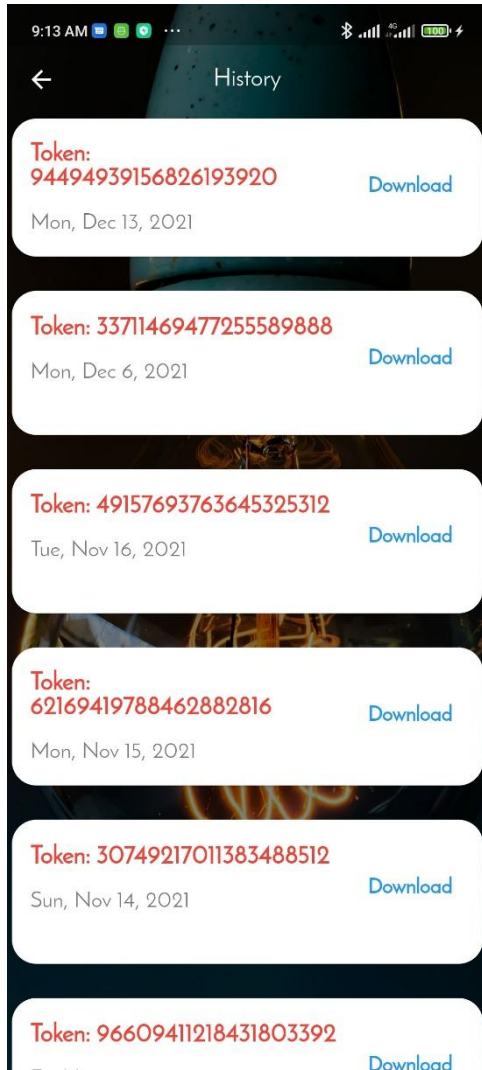


Figure 9: History Page

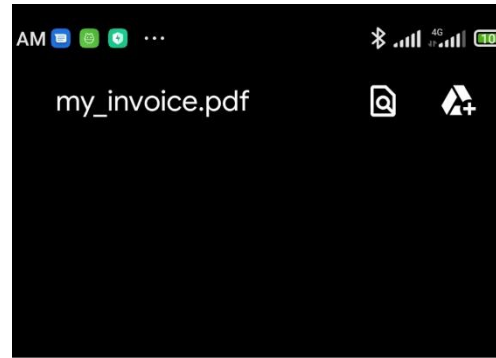


Figure 10: Download Receipt Page

4.1 Implementation Results

The application was test run on an android smartphone. Unit and Integration tests were carried out to identify defects and ensure that the product matched expected requirements. The result of this work is an application that provides several advantages which include:

- 1. Availability:** Since the new system is online it is available around the clock to all customers. If deployed customers will be able to make purchases at any time on weekdays, weekends, and public holidays.
- 2. Convenience:** Our application removes the need for customers to go to the bank and vending office. There is an increase in convenience as customers will be able to make purchases at anytime and anywhere (e.g., home, office, someplace outside the city).
- 3. Speed of Purchase:** With increased availability and convenience, the length of time it usually takes for customers to obtain their meter token is significantly reduced. The duration of the entire purchase process is reduced to just a few minutes all things being



equal.

For the next phase of this work, the application will be deployed and comprehensive evaluations and acceptance tests will be carried out. This will help us to undertake a comparative evaluation between the existing manual approach and our proffered digital approach to electricity purchase.

4.2 Conclusion and Recommendation

Many years ago, payment with raw cash was the dominant form of payment businesses could accept from their customers for purchasing goods and services. Today, consumers make electronic payments with credit, debit, and prepaid cards through different electronic devices ranging from smart watches to ATMs. As people gradually shift towards cashless economy, where electronic payments are widely accepted for routine and frequent purchases, the use case for payment services becomes more compelling [11]. This paper highlights the need for electronic payment methods to be adopted as an alternative mode of payment for small and large businesses. DISCOs should adopt this mode of payment to provide an always available, fast, easy, and convenient payment experience to their customers. Online payment will continue to play an ever-growing and vital role in the development of e-commerce.

Further improvement could also include the integration of multiple payment gateways into the system to provide a variety of options for payment and mitigate the risk of downtime and outages.

5. REFERENCES

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