A Mobile-App Based Prepaid Power Management System

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## **Abstract**

In the past years, Kenya has been experiencing challenges within the prepaid power systems that have been used. This has affected both consumers and companies that use prepaid power because this system faces a challenge that are frustrating to the consumers such as manual token feeding, dependency on the grid connectivity for the verification of the token payment, no remote payment, and no clear consumption monitoring. These cause multiple inconveniences for the users such as the manual token input. Big companies and workplaces are also affected by this, causing massive losses in profit, and increasing operating costs, in big sectors such as the healthcare sector. Businesses that also deal with perishable goods also suffer loss of product and profits. Kenya power is also affected by this because a rift is created between the users and the power providers.

Efforts have been made to tackle these challenges, which include smart meters by Safaricom which was to track electricity usage remotely. However, the other gaps mentioned have not been addressed by these smart meters such as remote token purchase, and token quantity recommendations. To address these existing gaps, this project aims to develop a mobile app based prepaid power management system. This system will analyze power consumption and token quantity suggestion based on the past and current usage and include remote token purchases. This will make the consumer experience much better than it already is and increase the efficiency of the prepaid system. To achieve this goal, agile methodology will be used, specifically the scrum framework. Scrum provides a very flexible way of working on the system and will allow for continuous feedback. The deliverables that will be produced will include working system modules, user documentation, progress, reports, and adaptations that are based on the feedback received which will allow the solution to be very efficient.

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# **Chapter 1: Introduction**

## **Background**

In a century marked by rapid technological advancements and a demand for efficient energy solutions, Kenya Power stands as a giant in the world of innovation within the energy sector. With an aim to providing reliable and affordable electricity to homes, businesses, and industries across Kenya, Kenya Power recognizes the imperative need to modernize its infrastructure and improve energy management systems. This proposal outlines a transformative initiative that seeks to introduce Smart Meters into Kenya Power's operations, revolutionizing the way energy consumption is monitored, controlled, and billed. Though Kenya power has made several technological advancements it faces several problems that results into loses.

The current way for pre-paid power management by KPLC customers is coupled with many challenges. First, customers are forced to feed the meter manually which is time consuming. Secondly, dependency on grid connection for the meter to work, lack of remote payment, and lack of consumption monitoring. These issues cause inefficiency; such as the input of token numbers into the meters, connection to the grid when inputting the token numbers for the validation of payment because if the whole grid has a disruption the users cannot pay for the tokens, remote payment users cannot pay when they are far from the meter because the token number has to be entered physically so the home cannot be powered for anyone else in the house and food may go bad due to no power being supplied to the refrigerator.

Furthermore, Institutions such as schools and hospitals are affected by power interruptions due to token related issues and this affects the students learning. Businesses that use this token system are affected as well especially those that deal with highly perishable goods could decay because of the power interruptions, and this causes major losses. This also affects Kenya power because this strains customer relations with the firm which cause losses in profit.

To solve these challenges, Smart meters have been proposed by Safaricom (John Mutua, 2023). These smart meters enable accurate tracking of electricity usage and are able to send this data remotely to KPLC. However, there are gaps that have not been resolved in this system. These include token quantity recommendations to customers to suggest their power usage and giving them a number of tokens that will power their house for a certain period based on previous electricity usage data. Additionally, allowing for remote token purchase. This is a big gap because with the current systems consumers cannot feed their tokens to the meter when they are far from home. Lastly, promoting customer education because many users do not fully understand the prepaid system or how to read the data provided.

Due to these challenges and identified gaps in the pre-existing systems, this project’s purpose is to create a mobile application for prepaid power management by KPLC customers. This system will not only analyze usage data and suggest token quantities based on usage but also enable convenient remote token purchases. The biggest objective is to enhance the consumers’ experience and the efficient process of prepaid power management.

## **1.2 Problem Statement**

the current state of prepaid power management system in Kenya, which poses challenges to consumers, companies, and Kenya power themselves.

The problem originates from inefficiencies such as: token handling; manual input of token numbers which is time consuming and could be error prone processes for users, this inefficient process disrupts daily life, Inadequate remote access, the lack of a good mechanism for remote purchases of tokens restricts the ability to manage the accounts effectively when away from home, Dependency on the grid, the users have to rely on the grid being stable for the token to be processed,

The affected parties and the consequences incurred, Consumers, are affected by the inconvenience uncertainty and the future potential loss due to the ineffective system. Businesses face operational disruption, and multiple financial losses. And damage their reputations when they cannot provide their services on the demand. Technology providers may face limited technological advancements in the energy sectors which affect their growth. (Sharon wanga, 2023)

## **1.3 Aim**

The aim of this project is to develop a mobile app based prepaid power management system that enhances the process of purchasing, monitoring, and utilizing tokens by KPLC customers. this will enhance the customers experience and overall efficiency in Kenya’s electricity supply system.

## **1.4 Specific Objectives**

1. To conduct a study and analysis of the current prepaid power management system.
2. To review existing prepaid power management systems.
3. To review the gaps faced by the current prepaid power management system.
4. To design and develop a mobile app based prepaid power management system that effectively addresses the identified challenges.
5. To test the developed prepaid power management system.

## **Research questions**

1. What studies and analysis of the current prepaid power management system have been done.
2. What review the challenges faced by the current prepaid power management system have been done?
3. A review of the existing prepaid power management systems.
4. What mobile app has been designed and developed based prepaid power management system that effectively addresses the identified challenges.
5. What tests of the developed prepaid power management system have been done?

## **1.6 Justification**

The successful development of the system will benefit the various stakeholders including Kenya Power and Lighting Company. KPLC will experience enhanced operational efficiency, improve customer relations, and cost reductions. This advancement will position KPLC as a pioneer which will attract investments and contribute towards technological advancements in the electricity supply sector.

Consumer will benefit by the creation of a mobile app-based system that simplifies the token management, users gain control over their electricity consumption and supply, this stops the need for the physical meters and reducing the frustrating delays encountered in the existing payment system. This empowerment translates into a better quality of life.

Utility Companies will have improved efficiency, reduced customer service workloads, and improved customer satisfaction and relations. The system makes the process easier and reduce operational costs and contribute to a seamless electricity supply system.

This project allows digital transformation withing the electricity supply sector. By embracing the innovation and a smart grid solution, this positions Kenya as a pioneer in the east Africa region which allows for economic growth and inviting investments in the technology sector.

## **1.7 Scope**

The proposed research focuses on the production of a mobile app based prepaid power management system for the Electricity supply system in Kenya. The scope of this project has in depth research and analysis of the current prepaid power system, identification of challenges, and the design, development, and testing of the new solution using the Kotlin language which is based in the Android studio Tool for mobile phone application using the android system. It includes user friendly interfaces, algorithms to calculate electricity consumption and for monitoring, token purchase suggestions. The project does not involve the physical installation or the modification of the meters or the grid, but it will revolve around the production of a software solution to tackle the challenges faced with the existing system. The project’s boundaries are related to software design and the development and does not include the hardware involved in the existing systems.

### **1.7.1 Limitations**

The various limitations that may be encountered during the development of the project, technical constraints. The development of a mobile app based prepaid system can be susceptible to some technical constraints, including compatibility between different operating systems used by mobile phones such as android and IOS, and ensuring the seamless performance across vast number of devices. Regulatory Compliance, complying with the already existing regulations in the energy sector is critical, any change to these regulations during the project could impact the implementation of the system. User Adoption, the success of the system lies with the user’s adoption and acceptance of the system. Resource Constraints, Limited resources affect the development of the system. These include time period, budget, and personnel working on the project.

### **1.7.2 Delimitations**

To address the listed limitations several interventions, have to be made throughout the project, first a thorough testing and quality assurance process will be used to a reduce the technical constraints that will ensure the systems compatibility with different devices and operating systems. Close collaboration with relevant stakeholders in the and different regulatory bodies will be used to stay informed about any changes in the regulations if any, this will allow the continuing compliance of the regulations to take place. Adequate resource allocation, including the budget and people working on the system will be planned to adequately allocate resources. Lastly, the continuous monitoring and feedback collection during the first usage of the system by the users will allow for change to fit their preferences better and will allow the app to be adopted by them and provide high user satisfaction.

# **Chapter 2: Literature Review**

## **2.1 Introduction**

In the current rapidly evolving energy landscape era, the management of electricity has become a crucial concern for both consumers and utility providers. Prepaid power management systems have emerged as innovative solutions to address these challenges, offering users greater control over their energy usage while providing utilities with efficient tools for grid management. existing technologies and recent advancements within the realm of prepaid power management systems, shedding light on the evolving landscape of smart meters, mobile applications, RFID technology, load control devices, data analytics, and more. By exploring these technologies, companies gain insights into how they empower consumers, enhance efficiency, and contribute to sustainable energy practices, all of which are essential components in today's dynamic energy ecosystem

## **2.2 Prepaid Power management system**

This is an innovative solution that allows electricity consumers to pay for and manage their energy usage in advance. With this system, users purchase electricity credits upfront, much like a prepaid mobile phone plan. As they consume electricity, the credits are deducted accordingly. This system empowers consumers by providing real-time information about their energy consumption, encouraging efficient usage, and helping them stay within their budget. Prepaid power management systems are beneficial for both consumers and utilities. Consumers gain greater control over their energy expenses and are able to avoid unexpected bills, while utilities benefit from reduced payment collection issues and improved overall grid management. There are various existing technologies that have come up to better help customers cope with this system. With the systems there is always customer experiences which will be reviewed here

### **2.2.1 Existing technologies in the prepaid power management**

They include;

**Meters;** there are various smart meters developed over the years and are in use they offer real time monitoring of energy consumption these include;

Simple Prepaid Energy Meter Kit

Practical Prepaid Energy Meters

Power Accent Prepaid Energy Meter (EL-PRO-CUS, 2013-2022)

**Mobile Apps and Online Portals**: Mobile applications and online portals allow consumers to top up their prepaid accounts, check their balance, and receive notifications about their energy usage. A study published in the International Journal of Electrical Power & Energy Systems found that users who receive real-time notifications about their consumption tend to be more energy efficient. (Google Play Store, n.d.)

**RFID (Radio-Frequency Identification) Cards**: RFID technology is used to facilitate convenient and secure top-ups for prepaid electricity accounts. Research in the International Journal of Electrical Power & Energy Systems highlights the efficiency and accuracy of RFID-based systems in reducing errors and improving payment processes. (Rozita Teymourzadeh, 2013)

**Remote Disconnect and Reconnect**: Prepaid systems often incorporate remote disconnection and reconnection capabilities, allowing utilities to manage service remotely. According to research published in the Journal of Power Sources, this technology reduces the operational costs associated with manual disconnect and reconnect processes. (Law insider, n.d.)

**Load Control Devices**: Some prepaid systems include load control devices that enable utilities to manage peak demand by temporarily reducing power to certain appliances during high-demand periods. Research from the International Journal of Sustainable Energy shows how load control will lead to energy savings and grid stability. (LASOLAR, n.d.)

### **2.2.2 Consumer experience in the prepaid power management system**

Prepayment electricity metering has been embraced in Kenya since the year 2008 by Kenya Power & Lighting Company Limited. Little information is available to ascertain the customer satisfaction levels regarding prepaid electricity service among customers in Nairobi County. A study explored the level of adoption of prepaid electricity meters. Further, the study evaluated perceived efficiency levels and benefits among prepaid electricity customers. The results showed that consumers prefer the use of prepaid electricity meters despite the fact that most of them are yet to apply for a prepaid metering connection. The majority of the respondents were of the view that prepaid meters have helped them in managing their electricity consumption. The study also found that electricity consumers are satisfied with the services by Kenya Power. The outcome of this study offers feedback to the Kenya Power on the need to connect more customers who require prepaid meters. (Owiye Evans David 0., 2019)

## **2.3 Existing technologies in the prepaid power management system**

Prepaid power management systems have become increasingly popular in recent years, offering consumers some control over their electricity usage, and helping utilities manage demand more efficiently. Below are three reviewed existing prepaid power management systems, discussing how they work, their strengths, and their limitations.

### **2.3.1 Itron Electricity Prepaid System**

Itron's system integrates with smart meters and allows consumers to purchase electricity credits in advance. Customers receive information about their usage, allowing them to monitor and adjust their consumption. When their credit balance runs low, the system sends notifications for top-up (Itron, 2018).Its strengths are; real-time monitoring helps customers become more energy-conscious, convenient payment options, including mobile apps and online portals, and it also enables utilities to reduce revenue losses due to unpaid bills. Despite of its strengths it also has several weaknesses which are; higher costs for designing and implementing smart meters and the prepaid system, the system may not be accessible to customers without internet access, limited ability to address sudden spikes in energy demand.

### **2.3.2. KEPCO Prepaid Metering System (Korea Electric Power Corporation)**

KEPCO's system utilizes RFID (Radio-Frequency Identification) cards for payments. Customers purchase these cards, which contain credits, and swipe them on the meter to load credits. The meter displays usage information, and customers receive SMS alerts when their balance is low. The system’s strengths are; it is simple and has a widely accessible payment method, there is reduced administrative costs for utilities, it helps customers avoid unexpected bills and control their expenses. In addition to the strengths the limitations of the system are; it requires physical card distribution which causes inconvenience, it is limited to areas with cellular network coverage for SMS alerts.

### **2.3.3. Nairobi City County Prepaid Electricity System**

In 2009, the Kenya Power unveiled the pre-paid electricity meters for domestic users within Nairobi and in other towns like Kisumu. The introduction of prepaid metering by the company was prompted by the fact that the postpaid system had various challenges which included inefficient monitoring of consumption, wrong meter reading, ineffective revenue collection and inefficient energy use. (Mwenemeru, 2015). the strengths of Nairobi’s prepaid system are; Smarter Power Distribution the system helps utility companies manage electricity distribution more effectively, better customer service: Utility companies will be able to offer improved customer service with online account management, prepaid meters are straight forward to install and replace, meaning less disruption for customers. However, the prepayment system had various shortcomings like faulty targets, poor consumer knowledge on how to use the modern technology and confusing billings.

## **2.4 Gaps in existing systems**

### **2.4.1: Token Handling (Manual Input)**

1. Itron Prepaid Electricity Management System: While Itron's system offers digital payment options, it may still involve manual input when purchasing physical credits, potentially leading to time-consuming and error processes for users.
2. KEPCO Prepaid Metering System: KEPCO's system uses RFID cards, reducing manual token handling, but customers still need to physically purchase and swipe these cards,
3. Nairobi City County Prepaid Electricity System: Nairobi City County's system relies on manual input of tokens, making it prone to errors and time-consuming for users.

### **2.4.2: Inadequate Remote Access**

Itron Prepaid Electricity Management System: While Itron's system provides real-time monitoring and digital payment options, it may still be limited by the availability of an internet connection or smartphone access, limiting remote access for some users.

KEPCO Prepaid Metering System: KEPCO's system primarily relies on physical cards for payments, which is inconvenient for remote account management.

Nairobi City County Prepaid Electricity System: This system has digital remote payment options; however, the gadgets are faulty.

### **2.4.3: Dependency on the Grid**

Itron Prepaid Electricity Management System: Like most prepaid systems, Itron's solution depends on a stable grid for processing payments. Power interruptions disrupt the token processing system.

KEPCO Prepaid Metering System: Similar to other prepaid systems, KEPCO's solution is also dependent on grid stability, and power outages affect the token processing system.

Nairobi City County Prepaid Electricity System: Nairobi City County's system is reliant on a stable grid, interruptions in power supply impact the processing of tokens.

## **2.5 Conceptual framework**

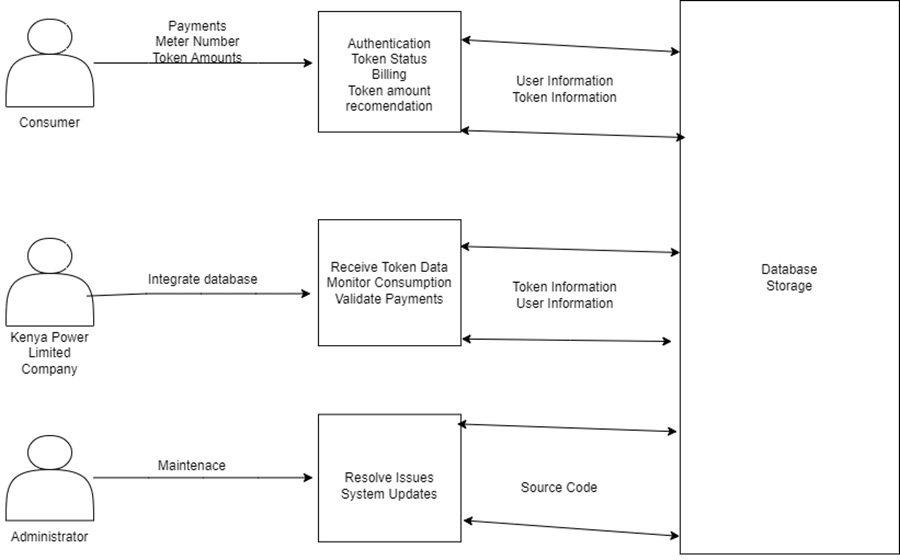


Figure 1:Conceptual Framework

The conceptual Framework show how the program will work in relation to the different users who will be able to access the program.

The Consumer includes normal users as well as businesses. The users will be able to Make payments, check their Token Status, get token amount recommendation, and authenticate themselves by signing in with their accounts. Kenya Power Lighting Company has a role to play which will be to integrate the existing database with the new system. They will also be able to Receive token data from different users, monitor the consumption, and validate payments. Then there will be the Administrator. The role of the administrator will be to maintain the program and resolve issues that users will be facing.

All the different users in the system will be connected to A database which will store Information about the user and Token information

## **Chapter 3: Methodology**

## **3.1 Introduction**

This chapter summarizes the methodologies, requirement engineering, and tools used in the solution that will be made. It outlines the different software to be used, the software development approach and the activities in each stage.

## **3.2 Research paradigm**

For this research, the solution shall take the Object-oriented analysis and design approach. This approach is to be used due to the multiple parts and complexity of the development of the solution. OOAD provides a very complete structure for planning and designing the solution, this allows for a noticeably clear understanding of its different abilities and multiple functions. The use of OOAD works well with current software engineering norms which makes this a suitable way for developing a complete and functional solution. (Peter, 2023).

## **3.3 Methodology**

The chosen methodology for the solution is the agile methodology specifically the rapid application development approach. It is a very flexible and adaptive methodology known for its speed in the development of programs. RAD allows for allows for continuous feedback and ensures that the solution will go along with the user requirements. The Methodology is well suited to the challenges in prepaid power management, as it enables the fast creation of working prototypes, leading to a more efficient development process (Venkata, 2020).



Figure 3. 1: Rapid Application Development

Requirements Planning, this is the initial phase. During this stage, the project team will partner up with the stakeholders to gather and define the requirements needed in the program. These requirements are recorded in detail, this will ensure a clear understanding of what the program will need to do.

The RAD (Rapid Application Development), this phase is where the development will take place . It entails rapid prototyping which will shorten the development. In RAD, working prototypes are built quickly, this will allow the stakeholders involved to see the functionality in action. Feedback is important in this phase to allow for any changes to be integrated early.

Construction, the construction phase focuses on building the final application. The final application will be based on the feedback given and the prototypes developed during the RAD stage. It involves writing code, integration of different components, and testing. This phase aims to create a fully functional application that will follow the requirements recorded before.

Cutover, this phase involves moving from a development environment to the production environment. This phase includes tasks such as final testing, data migration, ensuring the necessary resources are there for the application to continue working. A successful cutover is crucial to ensure a smooth transition and a complete program.

### **3.3.1 Requirements Planning**

To understand the problem at hand thoroughly, the research will involve collection of data for the requirements through surveys, interviews, and a review of the already existing literature. Interviews are good for collecting the requirements because they reach a large section of the population, they are easy to be carried out, and allow unique data to be acquired (Clements, 2023). Surveys are also good for collecting data from people because they are easy to administer, they are developed in a short amount of time, and a broad range of data is collected (DeFranzo, 2023). The functional and nonfunctional requirements will be specific and will focus on high system performance, security, and user needs. This step is especially important because it will the scope and goals of the solution to be identified and to ensure the solution goes along with the identified challenges.

### **3.3.2 Analysis and design**

The project will be using the OOAD approach. The diagrams used are the analysis diagrams, use case diagrams, sequence diagrams, and entity relationship diagrams these will be used to illustrate how the systems data will flow and the inner working and relationships between different data and the users involved for a complete experience. UML (Unified Modelling Language) will be used to create these different diagrams.

### **3.3.3 Construction**

The solution to be developed is going to be a mobile application, which has been chosen for its easy accessibility and user friendliness. The use of RAD will enable the system to be developed fast with minimal errors and will be a complete system because of the feedback being given in order to improve the quality. The front and back-end tools will be selected to give the production process of the program an efficient, compatible, and easy time during the programming phase. The programming language that shall be used is the Kotlin language, which is suitable for android application development because it is open source, it is an object oriented language, it is able to run on multiple platforms, it is also the preferred language for android development, and it is very compatible with java (Codeacademy, 2021). The IDE used for this program will be Android studio, the reason for this choice is because it an easy to use IDE, it already comes with kotlin and supports it greatly, it allows for templates and sample which is able to be used for a reference, and allows instant run because it automatically picks the changes and allows the program to be run without being rebuilt, this aids in the development process (Development, 2019).

### **3.3.4 Cutover**

To confirm the completeness of the solution, distinct types of testing will need to be conducted which include usability testing, functionality testing and security assessments. Usability testing will involve approaching users who are using the applications, this will evaluate the user friendliness of the application. The functionality testing will make sure that all the systems feature that are included work as intended, and security assessments will be used to validate the system’s resilience to any threats and breaches. These testing methods are going to be used to provide a complete secure option in the prepaid power management system landscape.

## **3.4 System Analysis and Design Diagrams**

### **3.4.1 Analysis Diagrams**

This solution will involve the use of Analysis diagrams, these diagrams are visual tools that help in the understanding, documenting, and analysing the structure of a system. The diagrams will provide a high-level view of all the systems components involved and how they work together in the system.

### **3.4.2 Use Case Diagrams**

Use case diagrams are important in this project to define, visualize, and document all the functional requirements of a system from a user’s perspective. They show different scenarios and relationships between users and the system.

### **3.4.3 Sequence Diagrams**

Sequence diagrams show the sequential order of any interactions that take place in the system between different components of a system. They are very useful when showing how different part of the program collaborate in order to complete tasks.

### **3.4.4 Entity Relationship Diagram (ERD)**

Entity Relationship Diagrams are important for database design which will be used in this solution. They are used to show the data models for a system. They illustrate the different entities, attributes, and the various relationships between them.

## **3.5 Deliverables**

The projects Deliverables include the user documentation, progress reports, independent system modules, and security measures.

# **Chapter 4: System Analysis and Design**

## **4.1 Introduction**

Chapter 4 of this document aims to provide a comprehensive understanding of the system's requirements, both functional and non-functional. It is essential to document these requirements to ensure that the system functions effectively and meets the needs of its users.

## **4.2 System Requirements**

In this section, we will delve into the specific system requirements, beginning with functional requirements for different user roles, including consumers, System administrators, and the Kenya Power and Lighting Company (KPLC). These requirements outline the core functionalities that the system must support to facilitate smooth interactions and operations.

### **4.2.1 Functional Requirements**

Functional requirements state what systems should be able to do, they define specific actions, functions, and capabilities that the system should have to achieve the user needs or objectives

#### **4.2.1.1 Login**

Users, both consumers, and administrators, should be able to log in securely. This feature ensures that the system's resources are accessed only by the authorized individuals.

#### **4.2.1.2 Enter Meter Number**

For consumers and KPLC administrators, the ability to enter a meter number is vital for accessing specific meter information such as location.

#### **4.2.1.3 Check User's Meter Information**

This functionality allows users to view and verify meter information, such as billing details, past usage.

#### **4.2.1.4 Create User Accounts**

Administrators should have the capability to create new consumer accounts. This is crucial for onboarding new consumers into the system.

#### **4.2.1.5 Purchase Tokens**

Consumers need the option to purchase electricity tokens through the system. This process should be user-friendly and secure.

#### **4.2.1.6 Receive Requests**

Both administrators and KPLC personnel should be able to receive requests from consumers. These requests may include inquiries, service requests, or complaints.

#### **4.2.1.7 Update User Credentials**

Users should have the ability to modify their login credentials, enhancing security and personalization.

#### **4.2.1.8 Request for Meter**

This feature enables consumers to request new meters, replacements, or upgrades as needed.

#### **4.2.1.9 Manage Requests**

Administrators and KPLC personnel should be able to efficiently manage and process incoming requests from users.

#### **4.2.1.10 Delete User Accounts**

Administrators should have the authority to delete user accounts when necessary, ensuring proper management of the system's user base.

#### **4.2.1.11 Input Locations**

Consumers should be able to input their location data, which is essential for efficient service provision and issue resolution.

#### **4.2.1.12 Log Out**

Users should be able to log out securely, ensuring the protection of their accounts and data.

### **4.2.2 Non-Functional Requirements**

Non-functional requirements are constraints that dictate the system's behaviour. These include elements such as security, safety, runtime performance, and more. It's important to implement these constraints effectively to ensure the system operates optimally and safely.

#### **4.2.2.1 Security**

Security measures will be implemented to protect user data and system integrity. This includes encryption, authentication, and access control mechanisms.

#### **4.2.2.2 Runtime Performance**

The system should be designed to perform efficiently, ensuring that operations are swift and responsive, even under heavy user loads.

## **4.3 Analysis and design diagrams**

### **4.3.1 Use Case Diagram**

The use case Diagram bellow shows the 3 main users which include the System administrator, kplc administrator, and the consumer. These users each have their respective actions that they can perform.

A screen shot of a diagram

Description automatically generated

1: Use case diagram

### **4.3.2 Class diagram**

The class diagram bellow shows all the the classes involved in the system and the relationships involved such as the one to many or many to many relationships.

A computer screen shot of a computer

Description automatically generated

2: Class Diagram

### **4.3.3 Entity Relationship Diagram**

This diagram shows all the entities involved in the system such as the different users and variables they have.

A black background with white squares

Description automatically generated

3: ER Diagram

### **4.3.4 Database Schema**

The diagram mainly helps to show the relationships between the entities and attributes that they have as shown in the ERD

A diagram of a customer

Description automatically generated

4: Database Schema

### **4.3.5 Sequence Diagram**

The sequence diagram shows the set of sequences that the system should follow A black and white background with white lines

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**5**Sequence Diagram

### **4.3.6 Wireframe Diagrams**

This diagram shows how the system will look like.

A screenshot of a computer screen

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6Wireframe Siagram

# **Chapter 5: Development and Testing**

## **5.1 Introduction**

Upon the completion of the project, this chapter offers an overarching summary. It encompasses the development process, challenges faced, implementation evaluation, stakeholder interaction, and the robustness of testing procedures.

## **5.2 Setup Description**

The Prepaid Power Management System is an Android-based solution developed using Kotlin in Android Studio. It encompasses a comprehensive architecture that incorporates functionalities catering to consumer, administrative, and utility management requirements.

### **Consumer Module:**

Authentication: Consumers can log in securely using a username and password, providing access to their account.

Viewing Usage Details: Users can view the usage in the meter that they are currently registered with.

Purchasing Tokens: Allows consumers to buy power tokens, specifying the quantity required.

### **Administrative Module:**

User Management: Administrators can manage consumer accounts, including creation, modification, or deletion.

## **KPLC Administrative module**

Usage Monitoring: they can view usage of any meter belonging to a customer.

### **5.2.1 Solution Setup**

**Tools used:**

The application is primarily developed using Kotlin and Java using the Android Studio IDE, which allowed the incorporation of SQL within Java code to interact with the SQLite database. SQLite serves as the database engine, providing a lightweight yet powerful solution perfectly suited for mobile applications, managing and storing consumer information, tokens, and meter data efficiently.

#### **Front-end and Backend:**

The front-end development in the system was mainly accomplished using Kotlin. Kotlin facilitated the creation of the user-friendly interface mainly considering the basic functionality and structure. The User Interface elements such as buttons, text fields, layouts and the page itself, were structured and designed using XML, ensuring a responsive visual presentation.

The backend functionalities were made using Java, Within the Java code, SQL queries were used to interact with the SQLite database, facilitating data retrieval, storage, and manipulation. The integration allowed for seamless data flow and facilitated basic functionalities like user authentication, token purchases, and usage tracking within the database.

**Environment**

The system is designed to function effectively within API version 34, providing support for older android devices as well as the latest android versions such as android 14. This compatibility allows us to access a numerous number of android devices which will allow for a broader user base, allowing users with varied Android devices to utilize the application seamlessly.

Moreover, the system uses Java version 8, incorporating its features and functionalities to enhance the application's backend operations. Java 8 brings forth a range of capabilities that contribute to the system's stability, security, and performance, ensuring efficient data processing, connectivity, and interaction between the frontend and backend components of the application.

**Backup**To ensure a reliable backup system for system, GitHub was employed as a primary option for storing and safeguarding the essential project files. GitHub served as the centralized platform for version control, allowing for the secure storage and management of the system's code. Through regular commits and updates, the important files, including the frontend and backend files, and database configurations were backed up on GitHub. This approach allowed for collaborative development. In case of unexpected loss or corruption of the files, the project can be restored to previous versions or stages, ensuring the integrity and continuity of the development process.

**5.2.2 Stakeholder Interaction**

**Consumer/Stakeholder Interaction:**

Login: Consumers interact with the system primarily through the login process. They log in to access functionalities and manage their usage and token purchases.

Token Purchase: Consumers can buy tokens for their meters, enabling them to utilize electricity. This interaction involves financial transactions and reflects consumer engagement with the prepaid power service.

Usage Monitoring: Consumers engage with the system to monitor their electricity usage.

Meter Request: Interaction involves consumers requesting new meters.

**System Administrator Interaction:**

User Management: Administrators handle user accounts, including creation, modification, and deletion of consumer accounts.

Monitoring and Maintenance: Administrators oversee the system's overall performance.

**KPLC Administrator Interaction:**

Usage Verification: KPLC administrators verify usage data and perform checks on specific meters.

**5.2.3 Challenges**

Implementation Deviations:

Database Integration Hurdles: Efforts to integrate databases like Room and MySQL were brought to a stop by compile-time errors, metadata errors and IDE compatibility issues. Throughout the development we conducted rigorous troubleshooting, reviewed documentation, and sought community support, but the issues persisted.

Despite the obstacles that we encountered, we looked for alternative database solutions and found that using an SQLite database to meet performance and storage requirements was the best option. Although this workaround was successful, it only allowed us to use a local database in which the files are stored locally on one’s device and rather than an online database that can allow multiple devices to connect to and perform functions.

## **5.3 Testing**

Testing Methodology:

The testing methodology used in this case was user driven testing which included us approaching real consumers and having them interact with the app or certain functions.

**5.3.1 Test Case: Basic Functions - Usage, Buy Tokens, Request Meter**

**Objective:**

Validate the fundamental functionalities of the system, usage tracking, token purchasing, and meter request operations.

**Test Steps:**

Request Meter: Log in as a user, access the meter request page, and request for a new meter by entering the location and the customer number and submitting the form.

Usage Tracking: Input valid meter number and click search button to give you the usage in a text field below.

Buy Tokens: enter appropriate credentials which include the customer id meter number and amount of tokens and update the database.

**Test Environment**: Android Device with android version 13

**Tools used**: Android Phone, laptop with DB Browser.

**Expected Result:**

The usage page displays accurate and updated usage data.

Successful purchase of tokens with reflected changes in the token quantity.

Successful request for meter and meter information updated.

**Actual Result:**

All basic functions including usage tracking, token purchasing, and meter requests were executed successfully as shown in appendix 2. The usage statistics were accurate, token purchases reflected in the database as shown in appendix 3, and the meter request was completed without issues.

**5.3.2 Test Case: Administrator Functionality - User Account Management**

**Objective:**

Validate the administrator's capability to create, update, and delete user accounts within the Prepaid Power Management System.

**Test Steps:**

Create User Account: Log in as an administrator, navigate to the user creation section, and create a new user account. Ensure the Name and Password fields are properly filled, and the account creation is successful. It will notify the admin if the creation is successful.

Update User Account: Access an existing user account, modify the account details which include the username and password, and save the changes. Verify that the updates reflect correctly in the database by checking DB browser.

Delete User Account: Select a user account by entering the customer ID and name, and then confirm the account deletion. Validate that the account is successfully removed from the system.

**Test Environment:** Android Device with android version 13

**Tools Used:** DB Browser

**Expected Result:**

Successful creation of a new user account with all required details.

Accurate reflection of updated user account details in the database.

Successful deletion of the selected user account without errors.

**Actual Result:**

All administrator functionalities - creating, updating, and deleting user accounts - were executed successfully as shown in appendix 4. New user accounts were created, updates accurately reflected in the database as shown in appendix 5, and the deletion process removed the selected user account without issues.

**5.3.3 Test Case: KPLC Administrator - Meter Information Check**

**Objective:**

Validate the KPLC administrator's ability to check the meter details for any meter within the system.

**Test Steps:**

Log In: Access the system using the KPLC administrator credentials.

Navigate to Meter Information Check Page: Locate and access the functionality dedicated to checking meter usage.

Select Meter: Choose a specific meter by entering it manually into the text field.

Verify Meter Details: Confirm that the Meter information displayed corresponds to the selected meter ID. Ensure accuracy in the data presented, including usage data and the information in the different columns of the meter.

**Test Environment:** Android Phone with android 13

**Tools Used:** DB Browser

**Expected Result:**

The KPLC administrator can successfully access the system, navigate to the Meter info check section, select a meter ID, and retrieve accurate details without any errors.

**Actual Result:**

The KPLC administrator successfully accessed the system, navigated to the usage check section, selected a specific meter/user ID shown in appendix 6, and obtained accurate usage details as expected. The displayed information matched the corresponding meter/user ID's usage without encountering any errors shown in appendix 7.

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# **Appendices**

A screen shot of a gantt chart

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Appendix 1: Gantt Chart

A screenshot of a computer

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Description automatically generatedA screenshot of a computer

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Appendix 2 request and viewing of usage of meters

A screenshot of a computer

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Appendix 3: successful output of request, purchase, and usage

A screenshot of a login form

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Description automatically generatedA screenshot of a phone

Description automatically generated

Appendix 4: System Administrator screenshots

A screenshot of a filter

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A screenshot of a computer

Description automatically generated

A screenshot of a computer

Description automatically generated

Appendix 5: Database Reflection

A screenshot of a computer

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Appendix 6: Meter information to be displayed

A screenshot of a phone

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Appendix 7: Meter information displayed