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Mobile Prepaid Meter (MoPM) using IoT (Internet of Things)

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Abstract: *This pioneering mobile application revolutionizes electricity management by seamlessly replacing traditional prepaid meter systems. At its core, the app empowers users to monitor and manage their electricity consumption with ease. Users can purchase and enter units for their homes conveniently, obviating the need for cumbersome payment methods. In addition to its fundamental purpose, the app boasts a suite of supplementary features that enhance its utility and value. Users receive real-time notifications and alerts, keeping them informed about power outages, low prepaid unit balances, and unusual energy consumption patterns. Predictive AI algorithms leverage historical data to forecast future energy consumption trends and costs, empowering users to make informed decisions. Users can export their data for analysis or sharing with relevant parties, ensuring data transparency and accountability. Swift emergency service reporting integration enables users to report electrical emergencies or outages directly to utility companies, streamlining response processes. This holistic solution not only replaces traditional prepaid meter systems but also introduces a new era of electricity management that prioritizes convenience, efficiency, and user empowerment*

Keywords: Electricity management, Efficiency, Predictive AI, User empowerment

I. INTRODUCTION

Electricity consumption and management have become paramount in modern society, with a growing emphasis on efficiency, accessibility, and user-friendly solutions. Traditional prepaid meter systems, though functional, have limitations in terms of user experience and real-time interaction. In response to these challenges, this project introduces a cutting-edge mobile application designed to revolutionize electricity management. The conventional method of electricity management relies on prepaid meter systems that require manual unit entry and offer limited real-time insights into consumption. Such systems have been associated with challenges such as disconnection inconveniences and a lack of transparency in billing. To address these issues, this project seeks to develop a mobile application that seamlessly replaces traditional prepaid meters. The application not only enables users to monitor and control their electricity consumption but also introduces innovative features, including real-time data access, predictive analytics, and IoT integration.

II. LITERATURE REVIEW

Electricity management is a critical aspect of modern life, with the need for efficient energy utilization and the demand for user-friendly solutions continually growing. Traditional prepaid meter systems, while serving as a foundation for billing and consumption monitoring, have faced limitations in terms of user experience and accessibility. In the realm of prepaid energy metering systems, several studies have been conducted to explore various approaches and their merits and demerits. This literature review aims to provide an overview of these studies, focusing on their key findings and potential areas for further research.

In the study conducted by **Kamble** and **Ghute** in **2020**, titled **"Design And Implementation Of Prepaid Energy Meter,"** the focus was on a web-based system, offering cross-platform compatibility. However, a notable drawback is its dependency on an active internet connection at all times, which may contribute to increased costs.

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The work presented by **Narmada, Lakshmaiah**, and **Nagamma** in **2015**, titled **"Design and Development of Pre-paid electricity billing using Raspberry Pi2,"** successfully demonstrated the monitoring of voltage and current. Nevertheless, a limitation of this system is its inability to facilitate the direct entry of units or tokens, posing a constraint on user convenience.

Adeyemo's 2021 study, **"A Mobile-Based Prepaid Electricity Metering System Using IoT,"** introduced mobile-based prepaid meters. While this offers enhanced accessibility, the integration of IoT increased system complexity. Additionally, the absence of a help and support feature in this implementation could potentially hinder user experience.

The **2013** review article by **Bao Wei** and **Jean-Michel Guilbert**, **"Energy Management in Smart Homes: A Review,"** provided comprehensive insights into energy management in smart homes. However, as a review article, it may lack specific implementation details and case studies, potentially leaving some readers seeking more practical application information.

The **2021** work by **Emmanuel Ampoma Affum** and **Kwame Agyeman-Prempeh**, **"Smart Home Energy Management System based on the Internet of Things (IoT),"** offered users real-time access to their energy consumption data. However, the requirement for payment could

III. METHODOLOGY

The methodology adopted here is the Agile methodology. The Agile methodology is a project management approach that involves breaking the project into phases and emphasizes continuous collaboration and improvement. I've tailored the Agile methodology to suit the solo development process.

Agile methodologies are well-suited for software development projects due to their flexibility, adaptability, and focus on delivering incremental value. By breaking the project into smaller, manageable phases or iterations, Agile allows for quicker feedback cycles, enabling adjustments to be made based on user input and changing requirements.

In this project, the Agile methodology is applied to the solo development process, meaning that as the sole developer, I have adapted Agile practices to suit my individual workflow and requirements. While Agile methodologies are typically associated with team-based collaboration, they can also be effectively applied in solo projects to promote efficiency, productivity, and quality outcomes.

The key principles of Agile, such as iterative development, continuous integration, and regular stakeholder feedback, remain fundamental to the solo development process. By embracing Agile practices, I can maintain flexibility, respond to changes quickly, and ensure the project stays aligned with user needs and expectations.

Throughout the development lifecycle, I leverage Agile techniques such as user stories, sprint planning, and retrospectives to drive progress and maintain momentum. By iteratively refining the project scope, prioritizing features, and incorporating feedback, I can deliver a high-quality solution that meets user requirements while adapting to evolving project constraints and objectives.

IV. ALGORITHMS

In this section, we explore the smart algorithms integrated into the Mobile Prepaid Meter Application. These algorithms are like the brains behind the system, enabling it to perform critical functions and provide advanced features:

Linear Regression

Linear regression is a statistical algorithm that plays a vital role in this project. Its primary function is to model the relationship between variables, allowing us to predict future energy consumption based on historical usage data. In this Mobile Prepaid Meter Application, linear regression serves as the foundation for forecasting energy consumption. By analyzing historical data, such as previous electricity usage patterns and corresponding costs, the algorithm identifies trends and relationships between variables.

Pattern recognition algorithm (e.g., hidden markov models)

Pattern recognition algorithms, including Hidden Markov Models (HMMs), play a crucial role in identifying anomalies or unusual consumption patterns in electricity usage data. These algorithms are essential for detecting irregularities and potential issues within the electricity management system. In this Mobile Prepaid Meter Application, Hidden Markov

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Models are employed to recognize unusual patterns or behaviors in electricity usage. These patterns could include sudden spikes in energy consumption, unusually low usage during typical high-usage periods, or any other deviations from expected norms. For instance, if a user typically consumes a consistent amount of electricity each day, an HMM can be used to monitor their usage. If the model detects a sudden and significant increase or decrease in usage that deviates from the usual pattern, it triggers an alert to notify the user. This helps users proactively address issues, such as potential equipment malfunctions or unauthorized usage, leading to more efficient energy management.
HMMs are used to detect anomalies or unusual consumption patterns in electricity usage data. Here's how it has been implemented:

V. SYSTEM DESIGN

System architecture

In this section, we present the overall architecture of the mobile prepaid meter system. We describe the high-level components, their interactions, and the system's organization. The system architecture is an important element of our electricity management project. It unites the components that are important to the system's operation:

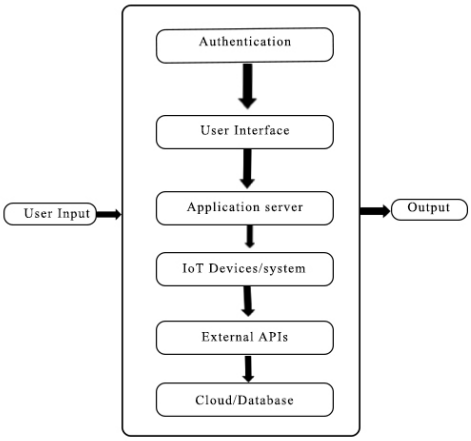

Figure 1. System architecture

Certainly! In our mobile prepaid meter application, the System Architecture Diagram outlines the flow of user interactions and data within our system. Our system begins with user input, leading to authentication and access to the user interface for tasks like checking balances. It then moves to the application server, connecting with IoT devices and external APIs for seamless integration. Data management is centralized in the database, ensuring real-time processing of user interactions. The system produces output, presenting information such as balance details and usage analytics to the user. This architecture diagram highlights the efficient flow of information in our application.

Use case diagram

The use case diagram visually represents the various interactions between system actors (users) and the mobile prepaid meter system. We illustrate the primary functionalities and features of the system, capturing the essential use cases that the application supports.

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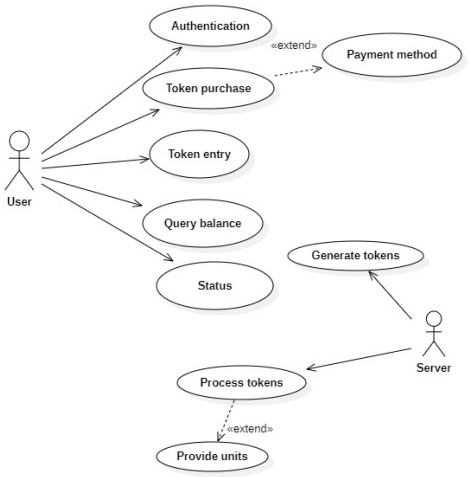

Figure 2 use case diagram

In our mobile prepaid meter application, the Use Case Diagram provides a vivid illustration of the dynamic interactions between users and the integral components of the system. At the core of this diagram is the primary actor, the 'User,' who initiates several pivotal actions shaping the user experience:

Data flow diagram

The data flow diagram (DFD) provides a visual representation of the flow of data within the electricity management system. It illustrates how data moves between different components of the system, highlighting the processes and interactions. The DFD helps in understanding how data is processed, transformed, and shared within the system. The DFD is an essential tool for system design and understanding data movement, ensuring efficient communication between system components.

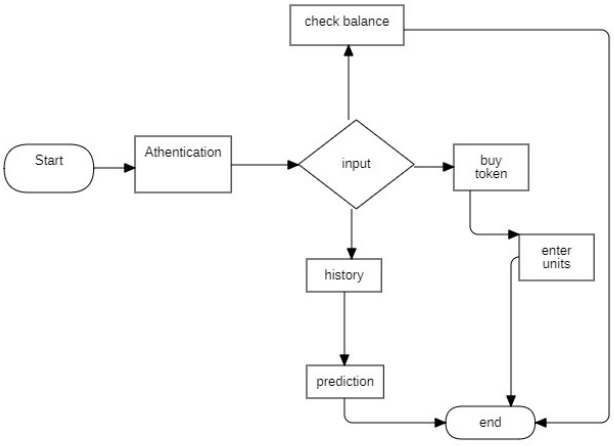

Figure 3. Dataflow diagram

Our Mobile Prepaid Meter application's Data Flow Diagram offers a clear depiction of how information dynamically moves through various components.

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VI. SYSTEM IMPLEMENTATION

Authentication

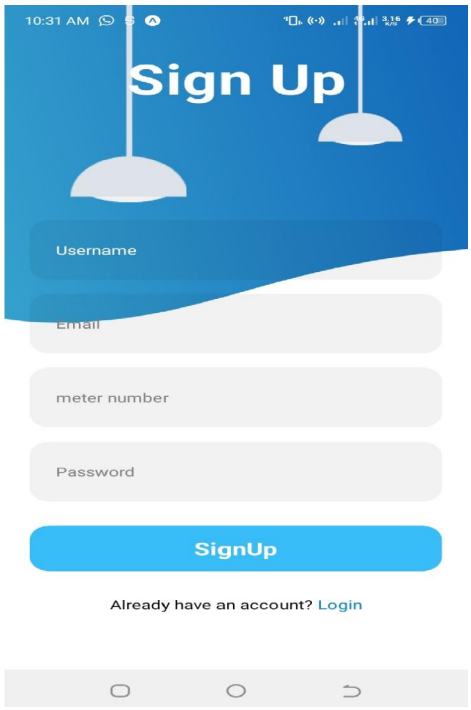

Figure 5: signup page

The signup page has a user input section includes animated form fields for 'Username,' 'Email,' 'Meter Number,' and 'Password,' each fading in with varying delays, providing a polished and dynamic appearance. Collection of these inputs helps in authentication of the program and ensuring a user-centric system.

Home page

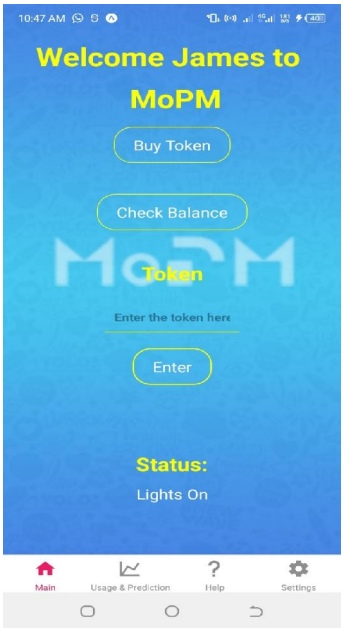

Figure 6: homepage

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The home Screen component constructs a visually appealing interface. The screen features various UI elements, including styled text, buttons, and input fields. Notably, there's a 'Buy Token' button triggering navigation to a modal screen and a 'Check Balance' button invoking a function to retrieve and display the user's balance from database. The user's balance is calculated based on historical data, considering both energy units consumed and the duration of consumption.

Help page

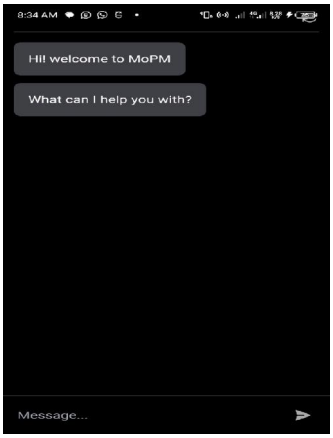

Figure 7: help page

This help section, which involves utilizing artificial intelligence algorithms to produce replies in real time that help the respective user accordingly. Every question concerning the MoPM application can be answered in this section, including how it operates.

Usage and prediction

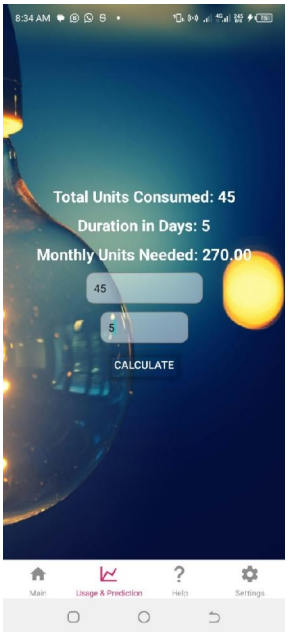

Figure 9: usage and prediction page

This section utilizes both linear regression and HMM algorithms to determine the units used as well as predict for a certain period of time in the app itself, it is divided into two sections and this is the second one. This section involves

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the history and prediction while the other one deals mainly with getting the usage data and supplying/feeding it to the system so that it can be used for the prediction.

V. CONCLUSION

The development journey of the Mobile Prepaid Meter Application, it's evident that our dedication to creating a user-centric, efficient, and secure platform has come to fruition. Through rigorous testing and refinement, we've crafted an application that not only meets but exceeds the expectations set at the project's inception. The application's core features, including token entry, balance checking, and purchasing, have been validated to ensure flawless functionality. The user interface has been fine-tuned for optimal usability, providing an intuitive and seamless experience. Security measures, such as data encryption and authentication protocols, have been rigorously tested, guaranteeing the protection of user data. As we conclude this phase, user satisfaction remains a top priority. The Mobile Prepaid Meter Application is poised to revolutionize electricity management, offering users a reliable, secure, and user-friendly solution. The success of this project lays a robust foundation for further advancements and improvements in the realm of smart energy management.

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